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It is a pleasure to commend the far-sighted policy of the Office of Naval Research, with its emphasis on basic research, as a result of which a grant has made possible the continuation of the Coral Atoll Program of the Pacific Science Board.

It is of interest to note historically, that much of the fundamental information on atolls of the Pacific was gathered by the U. S. Navy's South Pacific Exploring Expedition, over one hundred years ago, under the command of Captain Charles Wilkes. The continuing nature of such scientific interest by the Navy is shown by the support for the Pacific Science Board's research programs, CIMA, SIM, and ICCP, during the past six years. The Coral Atoll Program is a part of SIM.

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By

J. R. Moore, Jr.

THE RESEARCH JOURNAL

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CHECK LIST OF ATOLLS

Compiled for the Pacific Science Board

by E. H. Bryan, Jr.

The following is a list of islands which are believed to qualify as "atolls," as defined at the Coral Atoll Symposium, held in Honolulu, T.H., in February 1951. Included are non-elevated limestone structures with dry land, with or without a lagoon, and not associated closely with high land. Excluded are elevated atolls (height more than about 25 feet above the sea), sunken atolls (without dry land), barrier reefs surrounding high islands (such as the Truk group), and reef structures on fringing shelves or platforms adjacent to land masses (such as those on the Great Barrier Reef or to the north of western Java.)

This list is believed to contain most of the reef structures which qualify as "atolls" in Polynesia and Micronesia. The compiler is less familiar with the reefs of other regions, and it is not unlikely that some "atolls" have been overlooked. Additions and corrections are desired, and your help is solicited to make a future edition of this list as complete as possible. A number of suggestions have been received from Dr. F.R.Fosberg, and his help is gratefully acknowledged. Please send any data you may have to the writer at Bernice P. Bishop Museum, Honolulu 17, Hawaii. Please include the geographical coordinates of the reef, or reference to some chart or publication, from which its qualifications as an "atoll" may be verified.

The arrangement in this list is similar to that used in the author's various gazetteers of Pacific islands: a tabulation arranged geographically is followed by an alphabetical list of all the names, keyed to the first list by means of letters and numbers. The letters refer to logical, convenient, or established areas; the numbers to islands within the areas, in some definite sequence.

Under "notes", brief reference is made to such items of interest as elevations, number of islets, and the like; particularly those which might indicate that the reef is not a typical atoll. In the last column, reference is given to a chart which shows the atoll or its location. Most of the numbers refer to U. S. Hydrographic Office charts.

About 400 "atolls" are listed. Of these, 136 are in Polynesia, 92 in Micronesia, 66 in Melanesia, 15 in Indonesia, 5 northwest of Australia, 68 in the rest of the Indian Ocean, 26 in the Caribbean Sea, and only one in the Atlantic. The greatest number in any political subdivision is the 75 in the Tuamotu Archipelago; however, across the central Pacific and out through Micronesia there are 136, one group crowding close upon the heels of another. Notes scattered through this list explain uncertainties regarding the exact status of reef structures in various groups, such as the Louisiade Archipelago [which has been added as M'], Indonesia, the islands northwest of Australia, and the Caribbean region.

GEOGRAPHICAL LIST OF ATOLLS

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
A. EASTERN PACIFIC					
1.	Clipperton Island	1 39 N.	92 00 W.	Rock 62' high	1680
2.	Ducie Island	24 40 S.	124 48 W.	Trees 26 feet	1977
3.	Oeno Island (Martha Island)	23 56 S.	130 44 W.		1977
4.	Timoe Island (Crescent Island)	23 20 S.	134 30 W.	[Gambier Is.]	77
B. TUAMOTU ARCHIPELAGO (Paumotu, Low Islands)					
1.	Morane Island (Cadmus Island)	23 07 S.	137 07 W.		77
2.	Maria Island (Moerenhout Island)	22 01 S.	136 10 W.		77
3.	Maturei-vavao [Island] (Melbourne Island)	21 26 S.	136 25 W.	[Nos. 3 to 6 make up the Actaeon or Amphitrite Islands]	77
4.	Tenarunga Island (Minto Island)	21 19 S.	136 33 W.		77
5.	Vahanga Island (Bedford Island ?)	21 20 S.	136 39 W.		77
6.	Tenararo Island	21 19 S.	136 46 W.		77
7.	Fangatau Island (Fangataufa Island) (Ahunui Island) (Cockburn Island)	22 15 S.	138 42 W.		77
8.	South Marutea Island (Marutea Island) (Lord Hood(s) Island)	21 30 S.	135 30 W.		77
9.	Mururoa Island (Matilda Island) (Osnaburgh Island)	21 50 S.	138 55 W.		77 2004
10.	Tematangi Island (Bligh(s) Island)	21 40 S.	140 40 W.		77

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
B.					
11.	Tureia Island (Carysfort Island) (Papakena Island)	20 46 S.	138 31 W.		77
12.	Vanavana Island (Barrow Island) (Kuratake Island)	20 37 S.	139 08 W.		77
13.	Nukutipipi Island (Margaret Island)	20 42 S.	143 03 W.	[Nos 13-15 make up the Duke of Gloucester Islands]	77
14.	Anu-anu-runga Island (Four Crowns) (Quatro Coronades) (Teku Island)	20 38 S.	143 33 W.		84
15.	Anu-anu-raro Island (Archangel) (Heretua) (San Miguel Archangel)	20 28 S.	143 33 W.		77 84
16.	Hereheretue Island (Saint Paul Island) (San Pablo Island)	19 53 S.	145 05 W.		77 84
17.	Reao Island (Clermont de Tonnere I.) (Clermont-Tonnerre)	18 30 S.	136 20 W.		77 78
18.	Pukaruha Island (Searle Island)	18 20 S.	137 02 W.		77 78
19.	Tatakoto Island (Clerke Island) (Narcissus Island) (San Narciso)	17 20 S.	138 22 W.		77
20.	Pinaki Island (Whitsunday Island)	19 22 S.	138 42 W.		77
21.	Nukutaweke Island (Queen Charlotte I.)	19 46 S.	138 51 W.		77
22.	Vairaatea Island (Egmont Island)	19 18 S.	139 19 W.		77
23.	Vahitahi Island (Cook Lagoon) (Four Facardins) (Lagoon Island)	18 44 S.	138 52 W.		77

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
B. [TUAMOTU ARCHIPELAGO, Cont.]					
24.	Akiaki Island (Lancier Island) (Thrum Cap)	18 30 S.	139 14 W.		77
25.	Ahunui Island (Byam Martin Island)	19 40 S.	140 25 W.		77
26.	Paraca Island (Gloucester Island) (Hariri Island)	19 09 S.	140 43 W.		77
27.	Manuhangi Island (Cumberland Island)	19 11 S.	141 15 W.		77
28.	Nengonengo Island (L'Orange Island) (Prince William Henry I.)	18 50 S.	141 47 W.		77
29.	Hao Island (Bow Island) (Harp Island) (La Harpe Island)	18 10 S.	140 55 W.		77 2004
30.	Amanu Island (Moller Island)	17 48 S.	140 45 W.		77 2061
31.	Ravahere Island (Dawhaida Island)	18 13 S.	142 10 W.		77 79
32.	Marokau Island	18 03 S.	142 17 W.		77 79
33.	Reiteru Island (Bird Island)	17 48 S.	143 06 W.		77
34.	Haraiki Island (Croker Island) (St. Quentin Island)	17 28 S.	143 32 W.		77
35.	Hikueru Island (Melville Island)	17 36 S.	142 40 W.		77
36.	Tekokota Island (Doubtful Island)	17 19 S.	142 37 W.		77
37.	Tauere Island (Resolution Island) (St. Simeon Island)	17 22 S.	141 28 W.		77 83

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
B. [TUAMOTU ARCHIPELAGO, Cont.]					
38.	Rekareka Island (Good Hope Island)	16 49 S.	141 55 W.		77
39.	North Marutea Island (Furneaux Island) (Marutea Island)	17 00 S.	143 10 W.		77
40.	Nihiru Island (Nigeri Island)	16 43 S.	142 50 W.		77
41.	Pukapuka Island (Dog Island) (Henauke Island) (Honden Island)	14 56 S.	138 45 W.		77 83
42.	Fakahina Island (Fangahina Island)	15 59 S.	140 07 W.		77 2038
443.	Angatau Island (Arachecheeff Island) (Arakchev Island)	15 49 S.	140 51 W.		77
44.	Napuka Island (Wytochee Island)	14 09 S.	141 15 W.	[44 & 45 make up the Disappointment Group]	77 78
45.	Tepoto Island (Otocho Island)	14 05 S.	141 24 W.		77 78
46.	Takume Island (Wolchonsky Island) (Welkonsky Island)	15 45 S.	142 10 W.		77 83
47.	Raroia Island (Barclay de Tolley I.)	16 05 S.	142 23 W.	[1952 survey]	77 2024
48.	Taenga Island (Holt Island) (Yermaloff Island)	16 19 S.	143 06 W.		77
49.	Makemo Island (Koutouseff Island) (Phillips Island)	16 35 S.	143 20 - 144 W.		77 2037
50.	Katiu Island (Saken Island)	16 25 S.	144 20 W.		77
51.	Tuanake Island (Reid Island)	16 40 S.	144 14 W.	[51-53 make up the Raveski or Seagull group]	77 82

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
B.					
52.	Hiti Island	16 42 S.	144 08 W.		77, 83
53.	Tepoto Island (Eliza Island)	16 48 S.	144 17 W.		77, 83
54.	Motutinga Island (Adventure Island)	17 05 S.	144 22 W.		77
55.	Tahanea Island (Tchigschagoff I.)	16 56 S.	144 47 W.		77 2159
56.	Anaa Island (Chain Island)	17 25 S.	145 30 W.		77
57.	Faaite Island (Myloradowitich I.)	16 44 S.	145 15 W.		77
58.	Fakarava atoll (Wittgenstein Island)	16 20 S.	145 30 W.		77 2063
59.	Raraka Island	16 10 S.	144 50 W.		77, 80
60.	Taiaro Island (King's Island)	15 44 S.	144 37 W.		77, 79
61.	Kauehi Island (Vincennes Island)	15 50 S.	145 10 W.		77, 80 88
62.	Aratika Island (Carlshov Island) (Karlshoff Island)	15 33 S.	145 30 W.		77, 81
63.	Toau Island (Elizabeth atoll)	15 52 S.	146 - W.		77 2004
64.	Niau atoll (Greig atoll)	16 10 S.	146 20 W.		77
65.	Kaukura atoll	15 40 S.	146 49 W.	[65 to 67 called Palliser, Schadelyk, or Pernicious Islands.]	77
66.	Apataki Island (Hegemeister Island)	15 25 S.	146 20 W.		77, 81 2062
67.	Arutua Island (Rurick Island)	15 10 S.	146 45 W.		77
668.	Tikei Island (Romanzoff Island)	14 54 S.	144 32 W.		77
69.	Takaroa Island (Tiokea atoll)	14 27 S.	144 55 W.	[69-70, King George's group]	77, 81

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
B. [TUAMOTU ARCHIPELAGO Cont.]					
70.	Takapoto Island (Oura I., Ura atoll) (Taputa Island)	14 36 S.	145 12 W.		77, 81
71.	Manihi Island (Waterlandt Island) (Wilson's Island)	14 26 S.	145 55 W.		77, 82
72.	Ahe Island (Peacock Island)	14 30 S.	146 17 W.		77, 82
73.	Rangiroa Island (Deans Island) (Nairea atoll) (Rahiroa atoll) (Vliegen atoll)	15 05 S.	147 40 W.		77, 85 960
74.	Tikahau Island (Krusenstern Island)	15 00 S.	148 10 W.		77, 85
75.	Matahiva Island (Lazareff Island) (Mataiwa Island)	14 54 S.	148 40 W.		77, 85
C. AUSTRAL [1], SOCIETY [2-6], and MARQUESAS ISLANDS [7]					
1.	Maria Island (Hull Island) (Nororutu Island) (Sands Island)	21 49 S.	154 41 W.		2228
2.	Tetiaroa Island (Fugitive Island) (Tetuarea Island) (Umaitia Island)	17 05 S.	149 32 W.		77
3.	Tubai Island (Motu Iti)	16 16 S.	151 49 W.		2023
4.	Mopihaa Islands (Howe I., Lord Howe I.) (Maura Island) (Mobicdie Island) (Mopelia Island)	16 49 S.	153 57 W.		1987
5.	Fenua Ura (Scilly Islands)	16 30 S.	154 40 W.		824a
6.	Bellingshausen Island	15 50 S.	154 30 W.		824a
7.	Coral Island (Cotar Island) (Ile de Sable)	7 63 S.	140 23 W.		1797

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
D. CENTRAL PACIFIC (British South Equatorial [1-5], Equatorial [6,10,33,34], British North Equatorial [7,8,9], Cook [11,12], Northern Cook [13-19], Tokelau [22-24], Phoenix [25-32].					
1.	Caroline Island (Thornton I.)	10 00 S.	150 14 W.		1980
2.	Flint Island	11 26 S.	151 48 W.	No lagoon	1980
3.	Vostok Island (Anne I.) (Stavers I.) (Bostock I.) (Vostock I.) (Wostock I.)	10 06 S.	152 23 W.	No lagoon	1980
4.	Starbuck Island (Volunteer I.)	5 37 S.	155 53 W.	No lagoon	1980
5.	Malden Island (Independence I.) (Maldon I.)	4 03 S.	154 59 W.	Shallow lagoon entirely enclosed	1980
6.	Jarvis Island (Brock, Brook I.) (Bunker, Jervis I.) (Volunteer I.)	0 23 S.	160 02 W.	No lagoon, "pancake"	1198
7.	Christmas Island	1 55 N.	157 20 W.	Largest land area	1839
8.	Fanning Island (Tapuaerangi)	3 54 N.	159 23 W.		1824
9.	Washington Island (New York I.) (Prospect I.)	4 43 N.	160 26 W.	Bogs and fresh water lake	1839
10.	Palmyra Island (Samarang I.)	5 52 N.	162 06 W.		1839
10A.	Kingman Reef	6 23 N.	162 20 W.	Sunken atoll dry patch E end	2020
11.	Takutea Island (Fenua Iti) (Otakootaia)	19 49 S.	158 18 W.		2000
12.	Hervey Islands [Made up of:] Auotu or Te Au o Tu Manuae [I.]	19 21 S.	158 56 W.		2000
13.	Tongareva Island (Mangorongoro I.) (Penrhyn I.)	9 00 S.	158 03		1980
14.	Manihiki Island (Humphrey I.) (Manahiki I.)	10 23 S.	161 01 W.		1980

Key No.	Accepted name (Alternative names)	Latitude ° , ° ,	Longitude ° , ° ,	Notes	H.O. Chart
D. CENTRAL PACIFIC (cont.)					
15.	Rakahanga Island (Grand Duke Alexander) (Reirson I.)	10 02 S.	161 06 W.		1980
16.	Palmerston Islands (Auarua I.)	19 04 S.	163 10 W.		1980
17.	Suvarov Islands (Souworoff Is.) (Suwaroff, Suwarrow Is.)	13 15 S.	163 05 W.		1980
18.	Nassau Island (Mitchell I.)	11 33 S.	165 25 W.	No lagoon	1980
19.	Pukapuka [atoll] (Danger Islands)	10 55 S.	165 50 W.		1980
20.	Rose atoll (Kordinkoff I.)	14 33 S.	168 09 W.		2924
21.	Swains Island (Gente Hermosa) (Jenning's I.) (Olosenga, Quiros I.)	11 03 S.	171 05 W.	"Doughnut", nearly fresh lake	5419
22.	Fakaofu Island (Bowditch I.) (Fakaafo I.)	9 23 S.	171 15 W.		126
23.	Nukunono Island (Duke of Clarence I.)	9 10 S.	171 53 W.		126
24.	Atafu Island (Duke of York I.) (Oatafu I.)	8 32 S.	172 31 W.		126
25.	Sydney Island (Manra I.)	4 27 S.	171 16 W.	"Doughnut", very salt lagoon	5738
26.	Hull Island (Orona I.)	4 29 S.	172 10 W.		5737
27.	Gardner Island (Kenins I.) (Nikumaroro)	4 40 S.	174 32 W.		5738
28.	McKean Island	3 36 S.	174 08 W.	"Pancake" "dug" lagoon	5739
29.	Birnie Island	3 35 S.	171 31 W.	"Pancake"	5739
30.	Phoenix Island	3 43 S.	170 43 W.	Small lagoon	5739
31.	Enderbury Island	3 08 S.	171 05 W.	Small lagoon	5739
32.	Canton Island (Abariringa, Mary I.) (Mary Balcout I.) (Swallow I.)	2 50 S.	171 43 W.		5740
33.	Baker Island (New Nantucket, Phoebe I.)	0 13 N.	176 28 W.	"Pancake", no lagoon	1198

Key No.	Accepted name (Alternative names)	Latitude ° , °	Longitude ° , °	Notes	H.O. Chart
D. CENTRAL PACIFIC (cont.)					
34.	Howland Island (Worth I.)	0 48 N.	176 38 W.	"Pancake" no lagoon	1198
35.	Johnston Island (Cornwallis I.)	16 45 N.	169 30 W.	2 sand islets on shoal	5356

[There are no true atolls in Tonga, and none in Samoa other than Rose atoll. Swains I., administered by American Samoa, is geographically in the Tokelau (or Union) group. Minerva Reef has been called an "atoll", but is submerged.]

E. HAWAIIAN ISLANDS

1.	Laysan Island (Moller I.)	25 46 N.	171 44 W.	Shallow lagoon	2
2.	Lisianski Island (Pell, Laskar I.) (Lassion, Cladius I.) (Lisiansky I.)	26 04 N.	173 58 W.	No lagoon	
3.	Pearl and Hermes Reef	27 48 N.	175 51 W.	Atoll	
4.	Midway Islands (Brooks, Middlebrook Is.) (Massachusetts I.)	28 13 N.	177 23 W.	Atoll	1952
5.	Kure Island (Cure I., Ocean I.)	28 25 N.	178 25 W.	Atoll	

F. ELLICE ISLANDS

1.	Niulakita (Nurakita I.) (Sophia I.)	10 45 S.	179 30 E.		1981
2.	Nukulailai (Mitchell I.) (Nukulaelae)	9 22 S.	179 51 E.		1981
3.	Funafuti (Ellice atoll) (Fanaawa I.)	8 31 S.	179 08 E.		1802
4.	Nukufetau (De Peyster I.)	8 00 S.	178 29 E.		1981
5.	Vaitupu Island (Aitupu, Oaitupu I.) (Tracy I.)	7 28 S.	178 41 E.		1981
6.	Nui Island (Egg, Netherland I.)	7 16 S.	177 10 E.		1981
7.	Niutao Island (Lynx, Sepper I.) (Speiden I.)	6 06 S.	177 16 E.		1981
8.	Nanumanga Island (Hudson, Nanomana I.)	6 18 S.	176 21 E.		1981

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
(F. ELLICE ISLANDS cont.)					
9.	Nanumea Island (Nanomea I.) (St. Augustine Is.)	5 39 S.	176 08 E.		1981
G. GILBERT ISLANDS					
1.	Arorae Island (Arorai I., Hurd I.)	2 39 S.	176 49 E.	[No lagoon]	119
2.	Tamana Island (Rotcher I.)	2 32 S.	175 58 E.	[No lagoon]	119
3.	Onotoa Island (Clerk I.)	1 50 S.	175 33 E.		119
4.	Tabiteuea Island (Drummond I.) (Tapeteuea, Taputeuea I.)	1 25 S.	174 50 E.		119
5.	Nikunau Island (Byron I., Nukunau I.)	1 21 S.	176 28 E.	[No lagoon]	119
6.	Beru Island (Francis I., Peru I.)	1 20 S.	176 00 E.		119
7.	Nonouti Island (Nonuti, Sydenham I.)	0 40 S.	174 20 E.		121, 2179
8.	Aranuka Island (Henderville I.) (Nanouki I.)	0 10 N.	173 38 E.		122
9.	Kuria Islands (Woodle I.)	0 14 N.	173 25 E.	[No lagoon]	122
10.	Abemama Island (Apamama, Hopper I.)	0 21 N.	173 51 E.		122 4001, 4002
11.	Maiana Island (Hall I.)	1 00 N.	173 01 E.		122
12.	Tarawa Island (Cook I., Knox I.)	1 30 N.	173 00 E.	[AMS and war maps]	122
13.	Abaiang Island (Apaiang I., Apia I.) (Charlotte I.)	1 50 N.	173 02 E.		123
14.	Marakei Island (Maraki I., Matthew I.)	2 00 N.	173 20 E.		122
15.	Butaritari Island (Makin I., Taritari I.)	3 05 N.	172 50 E.	[AMS maps]	2179
16.	Little Makin Island (Makin I. ["Muggin"]) (Makin Meang, Pitts I.)	3 16 N.	172 58 E.	[AMS maps] [No lagoon]	

Key No.	Accepted name (Alternative names)	Latitude °	Longitude °	Notes	H.O. Chart
H. MARSHALL ISLANDS					
	(RATAK Chain, south to north)				
1.	Mili Atoll (Mille, Milli I.) (Mire, Miri To) (Mulgrave I.)	6 08 N.	171 57 E.	[AMS maps]	6001,6002
2.	Arno Atoll (Ahrno I.,Aruno To) (Daniel D.,Pedder I.)	7 05 N.	171 42 E.	[AMS maps]	6004,6005
3.	Majuro Atoll (Arrowsmith I.) (Madjuro I.,Mezyuro To)	7 07 N.	171 12 E.	[AMS]	F.2007,2008.
4.	Aur Atoll (Aurh I.,Auru To) (Ibbetson, Traversey I.)	8 15 N.	171 05 E.	[AMS maps]	6014
5.	Maloelap Atoll (Arakcheeff Is.) (Bass Reeftied, Calvert) (Kaven, Kawen) (Maloelab, Maroerappu To)	8 45 N.	171 00 E.	[AMS maps]	6014,6016
6.	Erikub Atoll (Erukuppu To) (Tschitschagoff)	9 08 N.	170 00 E.	[AMS maps]	6017
7.	Wotje Atoll (Odjia, Odtia) (Romanzoff,Romanzov,Romanzow) (Wotsch, Wozzie To)	9 28 N.	170 00 E.	[AMS]	6017,6018,6019
8.	Likiep Atoll (Count Heiden) (Likieb, Rikieppu To)	9 55 N.	169 08 E.	[AMS maps]	6020
9.	Jemo Island (Djemo,Temo,Timo) (Tiemo To)	10 08 N.	169 32 E.	[AMS maps]	5413,5427 (No lagoon)
10.	Ailuk Atoll (Ailu, Airukku To) (Tindal, Watts)	10 20 N.	169 57 E.	[AMS maps]	6022
11.	Mejit Island (Mejdit, Meziti To) (Miadi, New Year I.)	10 17 N.	170 53 E.	[AMS map]	5413 (No lagoon)
12.	Taka Atoll (Teke To) (Suvarov, Suwarow)	11 08 N.	168 38 E.	[AMS maps]	6023
13.	Utirik Atoll (Kutusov, Kutusow) (Utorokku To)	11 15 N.	169 48 E.	[AMS maps]	6023
14.	Bikar Atoll (Dawson, Pikaru To)	12 15 N.	170 05 E.	[AMS maps]	6024

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
(H. MARSHALL ISLANDS cont.)					
15.	Taongi or Pokak Atoll (Gaspar Rico) (Pokaakku To, Smyth I.) (RALIK Chain, south to north)	14 35 N.	168 58 E.	[AMS maps]	6024
16.	Ebon Atoll (Boston, Epon To)	4 38 N.	168 43 E.	[AMS maps]	5429
17.	Namorik Atoll (Baring, Namurikku To)	5 36 N.	168 07 E.		5429
18.	Kili Island (Hunter I., Kiri To)	5 39 N.	169 07 E.	[AMS map] (No lagoon)	5414
19.	Jaluit Atoll (Bonham, Djaluit) (Yaruto To) (Coquille [N.part]) (Elizabeth [S.part])	6 00 N.	169 35 E.	6007, 6008, 6010	
20.	Ailinglapalap Atoll (Airingurapurapu To) (Elmore, Odia) (pronounced "Eye-ling-lub-lub")	7 25 N.	168 45 E.		6011, 6012
21.	Jabwot Island (Djabwat I., Zyabatto To)	7 45 N.	168 59 E.	[AMS map] (No lagoon)	6011
22.	Namu Atoll (Namo, Nemu, Musquillo) (Lambert [N.part]) (Ross Is. [S.part])	8 00 N.	168 10 E.	[AMS maps]	6013
23.	Lib Island (Erippu To, Lip I.)	8 19 N.	167 24 E.	[AMS map] (No lagoon)	5428
24.	Lae Atoll (Brown, Lai, Rae To)	8 56 N.	166 15 E.	[AMS maps]	6036
25.	Ujae Atoll (Catherine, Katharine) (Udjae, Uzyae To)	9 04 N.	165 38 E.	[AMS maps]	5428
26.	Kwajalein Atoll (Kuezyerin To) (Kwedhelin & other variants) (Menschikoff, Mentschikow) (Catherine [N.part]) (Lydia [middle part]) (Margaretta [S.part])	9 05 N.	167 20 E.	[AMS maps] (Largest lagoon in Marshalls)	5428
27.	Wotho Atoll (Schanz, Uotto, Wotto To) (Wottho Inseln)	10 07 N.	165 58 E.	[AMS maps]	5427
28.	Ailinginae Atoll (Airinginae To)	11 08 N.	166 30 E.	[AMS maps]	6026

Key No.	Accepted name	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
(H. MARSHALL ISLANDS cont.)					
29.	Rongerik Atoll (Pescadore Is.) (Rongirikku To)	11 20 N.	167 27 E.	[AMS maps]	6026
30.	Rongelap Atoll (Rimski-Korsakoff Is.) (Rongelab, Rongorappu To)	11 20 N.	166 50 E.	[AMS maps]	6029
31.	Bikini Atoll (Bigini, Pikinni To) (Escholtz, Eschscholtz)	11 35 N.	165 23 E.	[AMS maps] (Atomic tests)	6032
32.	Eniwetok Atoll (Brown, Eniaidok) (Eniwetakku To)	11 30 N.	162 15 E.	[AMS maps] (Atomic tests)	6033
33.	Ujelang Atoll (Arecifos, Providence) (Udjelang, Uziran To)	9 50 N.	160 55 E.	[AMS maps]	6035
I. ISOLATED ISLANDS IN NORTHWEST PACIFIC					
1.	Wake Island or Atoll (Halcyon, Mendana) (San Francisco, Otori Jima) (Wakes I.)	19 17 N.	166 35 E.	[AMS map]	162
2.	Marcus Island (Minami Tori Shima)	24 18 N.	153 58 E.	(No lagoon)	5590
3.	Parece Vela (Douglas Reef)	20 25 N.	136 05 E.	(Reported 10 ft. elev.)	5590
J. CAROLINE ISLANDS (east to west)					
1.	Pingelap Atoll (McAskill, Macaskill) (Musgrave, Pelelap, Pelelep) (Pingarappu To, Pingoulap)	6 13 N.	160 41 E.		5425
2.	Mokil Atoll (Duperry, Duperrey) (Mokiru To, Mogal) (Wellington I.)	6 40 N.	159 46 E.		5425
3.	Ant Atoll (Andema, Anto To) (Fraser, William the Fourth)	6 54 N.	157 58 E.		6039, 6041
4.	Pakin Atoll (Pagenema, Paguenema)	7 03 N.	157 48 E.		6039
5.	Ngatik Atoll (Natikku To, Los Valientes) (Raven, Seven Is.)	5 50 N.	157 48 E.		6042, 6108
6.	Oroluk Atoll (Baxotristo) (Oraluk, Ororukku To)	7 32 N.	155 18 E.		6043

Key No.	Accepted name (Alternative names)	Latitude ° :	Longitude ° :	Notes	H.O. Chart
(J. CAROLINE ISLANDS cont.)					
7.	Nukuoro Atoll (Dunkin, Monteverde) (Monteverdeson's group) (Nugoru To)	3 51 N.	154 58 E.		6042
8.	Kapingamarangi Atoll (Constantine, Greenwich) (Gurānitti To, Kabeneylon) (Kapen-Mailang, Makarama) (Pescadores, Pikiram)	1 03 N.	154 46 E.		6042
9.	Nomoi or Mortlock Islands (Lukunor-gruppe) (Mototokke Shoto)		[Made up of three atolls]		6044
a.	Etal Atoll (Etaru To, Naiad) (Namolctou)	5 35 N.	153 34 E.		6044
b.	Lukunor Atoll (Namonefeng, Rukunoru To)	5 31 N.	153 46 E.		6044
c.	Satawan Atoll (Satoan, Sataoan, Satowwan)	5 23 N.	153 35 E.		6044, 6045
10.	Namoluk Atoll (Harvest, Skiddy, Namorukku To)	5 55 N.	153 08 E.		5425
11.	Losap Atoll (Duperrey, Lossop-Inseln) (Louasappe, Lukeisel) (Rosoppu To, Royalist)	6 52 N.	152 42 E.		5424
12.	Nama Island (San Rafael, d'Urville-Insel)	7 00 N.	152 35 E.	(No lagoon)	5424
13.	Hall Islands		[Made up of two atolls]		
a.	Murilo Atoll (Morileu, Mourileu) (Muriro Shoto)	8 40 N.	152 12 E.		6052
b.	Nomwin Atoll (Fananou, Namoin) (Namolipiafane, Namuin Shoto)	8 31 N.	151 47 E.		6052, 6098, 6099
14.	East Fayu Island (East Faiu, Faieu) (Japan Fayu, Lütke I.) (Rukute To)	8 34 N.	151 22 E.	(No lagoon)	5425
15.	Kuop Atoll (Kimisisima Shoto) (Kunto Shoto, Royalist Is.)	7 04 N.	151 55 E.	[Immediately south of Truk, which is <u>not</u> an atoll.]	6046
16.	Namonuito Atoll (Aniaima, Bunkey) (Livingston, Lütke) (Onon, Onoun, Onoune) (Ororu Shoto, Remp, etc.)	8 45 N.	150 05 E.		5422

Key No.	Accepted name (Alternative names)	Latitude ° '	Longitude ° '	Notes	H.O. Chart
(J. CAROLINE ISLANDS cont.)					
17.	Pulap Atoll (Los Martires, Ollap) (Pollap, Pourappu To) (Pullop, Puttep, Tamatam) (Tametam, Temetam Is.)	7 35 N.	149 25 E.		5421
18.	Puluwat Atoll (Endabi, Enderby) (Kata, de Cata, Luguen) (Poloac, Poloat, Polowat) (Poulouote, Puluot, etc.)	7 21 N.	149 11 E.		5425
19.	Pulusuk Island (Haug, Hog, Hok, Houg) (San Bartolome, Saok, Saugk) (Sauugk, Schoug, Scheug, Schoog) (Shukku To, Socu, Sog, Sooughe) (Sougk, Souk, Sove, Shukku To)	6 41 N.	149 19 E.	(No lagoon)	5425
20.	Pikelot Island (Coquille, Bigali, Pigali) (Lydia, Pigoualao, Pigerotto To) (Pikela, Pyghella, etc.)	8 05 N.	147 38 E.	(No lagoon)	5425
21.	Satawal Island (Sataual, Satavan, Satawan) (Satuwal, Satowal, Satowalairak) (Sasaon, Setoan, Tucker)	7 21 N.	147 02 E.	(No lagoon)	5426
22.	West Fayu Island (Faliau, Faiyao) (Huiyao, West Faiu)	8 05 N.	146 44 E.	(No lagoon)	5426
23.	Lamotrek Atoll (Lamorsu To, Lamureck) (Lamurrec, Namotikku To) (Namochikku To, Namouttek) (Namurrek, etc.)	7 30 N.	146 20 E.		6042
24.	Elato Atolls (Elat, Elath, Erato To) (Helato, Olutai, Olutel, Ylatu, etc.)	7 30 N.	146 10 E.	[Two atolls]	5426
25.	Olimarao Islands (Namoliaour, Olimarau) (Onomarai)	7 41 N.	145 52 E.	[Two islands: Olimarao and Filifil]	5426
26.	Gaferut Island (Grimes I., Gurimesu To)	9 14 N.	145 23 E.	(No lagoon)	6042
27.	Faraulep Atoll (Faraulip, Farroilap) (Fattoilap, Foraulep, Foroilap) (Furaarappu To, Huraarappu To)	8 36 N.	144 33 E.		6042
28.	Ifalik Atoll (Faloc, Furukku To, Hurukku To) (Ifaluk, Ifalouk, Ifelug, Ifeluk, etc.)	7 15 N.	144 27 E.		5425

Key No.	Accepted name (Alternative names)	Latitude ° ,	Longitude ° ,	Notes	H.O. Chart
(J. CAROLINE ISLANDS cont.)					
29.	Woleai Atoll (Anangai, Mereyon To) (Oleai, Oleei, Olie, Ouleai) (Ulea, Uleai, Ulie, Wolea, etc.)	7 21 N.	143 53 E.		6054
30.	Eauripik Atoll (Auripik, Aurupig, Iuripik) (Kama Is., Yeropie) (Yorupikku To, Yuripik, etc.)	6 41 N.	143 03 E.		5426
[Note: Fais Island is a raised reef structure.]					
31.	Sorol Atoll (Sarol, Saraon, Soral) (Sororu To, Phillip Is., Zaraqol)	8 08 N.	140 23 E.		5426
32.	Ulithi Atoll (Mackenzie Is., Ouluthy) (Uluthi, Urushi To)	9 56 N.	139 40 E.	6055, 6056, 6057	
33.	Ngulu Atoll (Anggul, Kurru To, Matelotas) (Lamoliaur Ulu, Lamoliork) (Lamuniur, Lumuliur, Ngelu) (Ngiul, Ngolu, Ngoli, Ngolii) (Ngoly, Ngolog)	8 27 N.	137 29 E.		6058
34a.	Ngaruangel Reef	8 10 N.	134 38 E.	[Reef has one islet, 6 ft.]	6074
34b.	Kayangel Islands (Kajangle, Kajanguru) (Kazanguru To, Moore Isle)	8 03 N.	134 43 E.	[Both these are in northern Palau]	6073, 6075
35.	Sonsorol Islands (Sonisol, Sonsol, Sonesor) (Sonsonorol, Sonesor, Songosor) (Sonsoru To, Kodgubi) (San Andreas, St. Andrew I.)	5 20 N.	132 13 E.	[Two small islands, no lagoon.]	5424
36.	Pulo Anna Island (Bur, Current, Palolo) (Pul, Pur, Puru Anna, Wul, Wull)	4 40 N.	131 58 E.	[No lagoon]	5426
37.	Merir Island (Merier, Meliel) (Pulo Marier, Warren Hastings)	4 19 N.	132 19 E.	[No lagoon]	5426
38.	Tobi Island (Lord North, Nevil I.) (Codopuei, Kadogubi) (Togobei, Tokobe)	3 00 N.	131 10 E.	[No lagoon]	5426
39.	Helen Reef (Heren Sho, Hoten Rif)	2 55 N.	131 47 E.	[Small, low islet at N. end]	6072
40.	Mapia Atoll (Freewill Is., Onata Is.) (St. David Is.)	0 50 N.	134 17 E.	[Not part of Micronesia, but claimed by Dutch]	5426

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
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K. FIJI

[Note: There are numerous reef structures in Fiji, but few of them qualify as "atolls" because of absence of dry land or proximity to high islands. Only two, Wailangilala and Nggelelevu, are classed as "true atolls" by R.A.Derrick, The Fiji Islands, a geographical handbook. 1951.]

- | | | | | | |
|----|--|----------|-----------|--|------|
| 1. | Tuvana-i-tholo
(Simonoff I.) | 21 02 S. | 178 50 W. | Small sand cay,
95 ft.to treetops,
surrounded by reefs | 409 |
| 2. | Tuvaba-i-ra
(Michaeloff I.) | 21 00 S. | 178 44 W. | Ditto, 90 ft. to
treetops. | 409 |
| 3. | Niambo Island | 18 57 S. | 178 22 W. | Ditto, 40 ft. to
treetops. | 2852 |
| 4. | Wailangilala Island | 16 45 S. | 179 07 W. | True atoll. | 2851 |
| 5. | Nanuku Reef
[Reef complex on or near
which are located:
Nukusemanu I. 60 ft.
Nuku-levu ("covered with trees")
Nuku-lailai I. " " "] | 16 45 S. | 179 27 W. | | 2851 |
| 6. | Nukumbasanga Reef
[Circular reef enclosing:
Nukumbasanga I. (70 ft.to treetops)
Nukumbalate I. (60 ft.to treetops)] | 16 17 S. | 179 15 W. | | 2851 |
| 7. | Nggelelevu Lagoon
[Atoll-like reef, on or near which are:
Taulalia I. (30 ft. to treetops)
Tainimbeka I. 40 " " "
Ngelelevu I. 90 " " "]] | 16 05 S. | 179 10 W. | | 2851 |
| 8. | Vataua Island | 15 57 S. | 179 24 W. | [90 ft.to treetops] | 2881 |

[Near atolls: Mbukatatanoa or Argo Reef has the reef structure of an atoll, but instead of sand islets on the reef there are two piles of rock, Vanua Masi and Bacon Island, in the lagoon.

Reid Reef is an atoll-like, circular reef containing three small, rocky islets: Latei Viti, Latei Tonga, and Booby Rock.

Vekai Rock is a reef rock on the edge of a circular reef, 2 miles in diameter, at 17°33' S., 178°50' W.

Two of the three Nukutolu Islands (17°17'S., 179°39' W.) are low, the third of raised reef material.]

L. WEST OF FIJI TO CORAL SEA (South of Solomon Islands)

- | | | | | | |
|----|--|----------|-----------|-------------------------------|------|
| 1. | Reef Islands
Rowa Island [50 ft. to treetops]
Sanna Island (I.de Sable) [50 ft.] | 13 35 S. | 167 33 E. | | 2877 |
| 2. | Conway Reef | 21 45 S. | 172 03 E. | [Sand cay, 6 ft.] | 1996 |
| 3. | Nokanhui Reef
(Hokanhiui) | 22 45 S. | 167 34 E. | [2 sand cays:
Ana and Ami] | 2871 |

Key No.	Accepted name (Alternative names)	Latitude °	Longitude °	Notes	H.O. Chart
(L. FIJI TO CORAL SEA, south of Solomon Is. cont.)					
4.	Uvea Atoll	20 35 S.	166 30 E.	Classed as an atoll, possibly raised.	2230
5.	Beautemps-Beaupre Atoll (Heo I.)	20 24 S.	166 10 E.		2230
6.	Petrie Reef (Betsy Reef)	18 27 S.	164 20 E.	(Land 20 ft.)	2027
7.	D'Entrecasteaux Reef Suprise I., Fabre I., Le Leizour I.	18 29 S.	163 07 E.	(Palms, 67 ft.)	2027
8.	Huon Island [& Lagoon]	18 03 S.	162 58 E.		2027
9.	Bampton Reefs				
	North Bampton Reef:				
	Renard Island	19 14 S.	159 00 E.	[20 ft.]	
	Southeast Bampton Reef	19 08 S.	158 40 E.	[17 ft.]	
10.	South Bellona Reef	21 52 S.	159 25 E.	[10 ft. sand I.]	2002
11.	Middle Bellona Reef	21 24 S.	158 51 E.	[6 ft. cay]	2002
12.	Chesterfield Reefs				2002
	Anchorage Islets	19 54 S.	158 29 E.	[38 ft.]	
	Loop Islet			[12 ft.]	
	Passage (Bennet) I.			[41 ft.]	
	Long Island	19 53 S.	158 19 E.	[25 ft.]	
13.	Avon Isles	19 32 S.	158 15 E.	[17 ft.]	2002
14.	Mellish Reef				
	Herald Bacon Island	17 25 S.	155 52 E.	[6 ft.]	2002
15.	Keen Reef	21 12 S.	155 45 E.	[6 ft. cay]	2002
16.	Cato Reef & Island	23 15 S.	155 32 E.	[19 ft.]	2002
17.	Wreck Reef	22 11 S.	155 20 E.	[18 & 12 ft.]	2002
18.	Frederick Reef	20 58 S.	154 23 E.	[2 cays, 5 ft.]	2002
19.	Saumarez Reefs	20 45 S.	153 40 E.	[2 cays, 8 ft.]	2002
20.	Marion Reef Carola Cay, Second Cay, Paget Cay	19 06 S.	152 24 E.	[3 cays, 5-10 ft.]	2567
21.	Lihon Reef	17 08 S.	152 07 E.	[6 cays, 6-19 ft.]	2941
22.	Diamond Islets	17 26 S.	150 59 E.		2941
23.	Tregrosse Islets	17 43 S.	150 43 E.	[2 small islets]	2941
24.	Coringa Islets Chilcott Islet Southwest Islet	16 57 S.	149 58 E.	[2 islets: 26 ft. to brushtop] 44 ft. to brushtop]	3568
25.	Herald Cays	16 56 S.	149 13 E.	[2 islets: 15-23 ft]	2942
26.	Magdelaine Cays	16 36 S.	150 20 E.	[25 ft. to brushtop]	2942
27.	Willis Islets Willis, Mid and North Islets	16 15 S.	150 00 E.	[3 islets: 19-22 to brushtop]	2002

[Note Middleton Reef and Elizabeth Reef are sunken atolls, awash.]

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
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M. North of the SOLOMON ISLANDS

- | | | | | | |
|----|--|---------|-----------|-------------------|------|
| 1. | Lord Howe Islands
or Ontong Java *
(Luangiua, Leueneuwa) | 5 20 S. | 159 30 E. | [1 of the islets] | 2910 |
| 2. | Nukumanu group
(Tasman Is.) | 4 32 S. | 159 26 E. | | 2899 |
| 3. | Tanu atoll [Tauu on chart]
(Marqueen Is.) | 4 50 S. | 154 24 E. | | 2896 |
| 4. | Kilinailau Islands
(Carteret Is.) | 4 44 S. | 155 24 E. | | 2896 |
| 5. | Nukuria or Nuguria Islands
(Abgaris or Abgarris atoll) | 3 20 S. | 154 40 E. | [2 atoll reefs] | 2943 |

[Note *: Lord Howe generally is given preference over Ontong Java, but should not be confused with other islands of the same name in the Banks group and east of Australia.

Roncador (Candelaria) 6° 13' S., 159° 20' E., is a circular atoll reef, but awash, without land other than rocks on the reef.]

M'. LOUISIADÉ Archipelago

[Note: There are numerous small, atoll-like reefs in this area, but the majority seem to make up a barrier reef around Tagula and adjacent high islands. The following may qualify as "atolls,"

- | | | | | | |
|----|---------------|----------|-----------|--------------------------------------|------|
| 1. | Bramble Haven | 11 14 S. | 152 00 E. | | 2950 |
| 2. | Long Reef | 11 11 S. | 151 45 E. | | 2950 |
| 3. | Redlick Islet | 10 55 S. | 152 33 E. | | 2950 |
| 4. | Conflict Reef | 10 45 S. | 151 45 E. | | 2950 |
| 5. | Gallows Reef | 10 16 S. | 151 10 E. | (2 islets on a
sunken atoll rim.) | 2950 |

N. ADMIRALTY Islands and westward.*

- | | | | | | |
|----|--|---------|-----------|------------|---------|
| 1. | Tong Islands
(San Rafael I.) | 2 03 S. | 147 45 E. | | BA.3832 |
| 2. | Papialou Islands
(Hayrick, Heuschauber) | 2 42 S. | 147 24 E. | | BA.3832 |
| 3. | Alim Island
(Elizabeth I.) | 2 52 S. | 147 07 E. | | BA.3832 |
| 4. | Johnston Islands | 2 25 S. | 147 05 E. | | BA.3832 |
| 5. | Purdy Islands
(Nager Is.) | 2 53 S. | 146 20 E. | (4 islets) | BA.3832 |

[* Note: Hermit Islands are a "Truk type" group of high islands surrounded by an atoll-like barrier reef. Doppel (Sherburne) Reef, Kreis (Circular) Reef, and the Whirlwind Reefs are all sunken atolls, without permanent dry land. Ottilien Reefs consist of four reefs which make up an atoll-like group, with a sand cay on the western reef. Other reef islands, such as Los Reyes, Pak, San Miguel Islands, and St. Andrews Islands, seem to be of raised reef formation.]

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Latitude ° ' "	Notes	H.D. Chart
(N. ADMIRALTY ISLANDS cont.)					
6.	Sabben Islands	2 12 S.	146 16 E.	Extensive reef	BA.3832
7.	Palawat Islands	1 56 S.	146 29 E.	3 low islets	BA.3832
8.	Western islets	2 13 S.	146 01 E.	Low islet	BA.3832
9.	Kaniet Islands (Anchorite Is.)	0 55 S.	145 30 E.	5 islets	BA.3832
10.	Sae Islands (Commerson Is.)	0 46 S.	145 15 E.	2 islets	BA.3832
[Nos.11-17 make up the NINIGO group]					
11.	Heina atoll	1 07 S.	144 30 E.	6 islets	2969
12.	Pelleluhu or Pelleluch atoll	1 08 S.	144 24 E.	12 islets all on E.side	2969
13.	Ninigo atoll (L'Echiquier)	1 15 S.	144 16 E.	28 islets	2969
14.	Sama "group"	1 24 S.	144 05 E.	3 islets	2969
15.	Sumasuma or Samusamu Island	1 28 S.	144 03 E.	1 islet	2969
16.	Awin and Maletin Islands	1 39 S.	144 03 E.	2 islets	2969
17.	Liot Island	1 24 S.	144 30 E.	1 islet	2969
18.	Manu Island (Allison I.)	1 18 S.	143 35 E.	Flat islet	BA.3832
19.	Aua Island (Durour)	1 28 S.	143 06 E.	120 ft.treetops may be raised	BA.3832
20.	Wuwulu Island (Maty I.)	1 43 S.	142 50 E.	May be raised	BA.3832
21.	Asia Islands	1 05 N.	131 15 E.	3 low islets	3003

P. INDONESIA [former East Indies]

[Notes: Atolls and raised coral islands in this area are listed by J.F.H.Umbgrove (Bulletin, Geological Society of America, 58 (8): 729-778, Aug. 1947). Although he distinguishes "raised atolls" and "almost atolls" from others, the same symbol is used for surface atolls and sunken atolls, and several are marked with a query. From available data it is difficult to determine the exact nature of many of the reef formations listed, especially those queried by Umbgrove himself.

The following are omitted from this list for the reasons given: Noekwendi (probably one of the Padaido Islands), no data; Ormsbee (sunken, -9 fathoms); Aurora (sunken, -7 fathoms); another, unnamed drowned atoll (-13 fathoms) between these two; Gisser, Goram, and Watoe [Watu] Bela, SE of Ceram (all seem to have closely associated high islands); Kabia, if the same as Kakabia or Baars Island [6° 54' S., 122° 13' E.] (raised, listed as having an elevation of 125 feet); Pasir Tengah and "East Atoll" [in the Gulf of Tomini,

(P. INDONESIA continued)

Celebes](lie in close proximity to the high Togra Islands); of the Sibutu group [north of Borneo] only one is of true atoll formation, that to the west being submerged and to the east, raised; various other reef islands, such as Amboengi and the Little Paternoster Islands [off the southeast curve of Borneo], and the Thousand Islands (including Dapur and Edam Islands) in the Bay of Batavia [north coast of Java] lie on platforms adjacent to high land masses.]

						H.O.
1. Noekori, Dauwi, Wamsoi and Roeni Islands	1°20' S. 136°40' E.	S.E. of Biak I. [Nature & status?]	3003			
2. Meatiij Mirarang (Brisbane I., Meati I.)	8 15 S. 128 25 E.	[In Sermata Is.]	3002			
3. Gosong Boni	8 25 S. 122 15 E.	[N. of Flores I.]	3002			
4. Angelica Shoal (Pasir Lajaran)	7 47 S. 122 20 E.	[Dries in places]	3002			
5. Tukang Besi Islands (Toekang Besi)		[Most of this group are high islands]	3002			
Karang Keledupa (Kg. Kaledoepea)	5 45 S. 123 45 E.	[Atoll-like, high ?]				
Karang Koka	6 04 S. 124 23 E.	[low reef islands?]				
Kenti Ole	5 45 S. 123 32 E.					
6. Tijger [Tiger] Islands (Taka Boné Raté)	6 50 S. 121 10 E.	[Islets scattered over intermittant reef]	3046			
7. Taka Garlarang	6 30 S. 121 15 E.	[Exact nature ?]	3002			
8. Zandbuis Banks (Sadapur)	7 47 S. 117 08 E.	[Also adjacent Maria Reigersbergen Banks]	3006			
9. Paternoster Islands: Pulo Tengah Kg. Kapoposang Bali Sailoes Saoedjoeng Tampoang Kg. Satoenggoel	7 30 S. 117 20 E.	[Several small islets on extensive reef complex]	3006			
POSTILJON Islands [10 and 11]						
10. Sapuka Islands (Sapoeka)	7 05 S. 118 10 E.	[S.W. group]	3006			
11. Sabalana Islands (Poeloe Sabalana) Soemanga I. Sabaroe I., etc.	6 50 S. 119 50 E.	[N.E. group]	3006			
12. Taka Rewataya (De Brill Bank)	6 05 S. 118 54 E.	[Sunken atoll ? light on SW edge]	3045			
13. Dewakang Kechil (Laars Island) Dewakang Besar	5 26 S. 118 22 E.		3045			
14. Kalu Kalukang (Kaloë Kaloekoeang)	5 12 S. 117 35 E.		3045			

Key No.	Accepted name (Alternative names)	Latitude ° ,	Longitude ° ,	Notes	H.O. Chart
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(P. INDONESIA continued)

15.	Muaras Reef (Moearas)	1 50 N.	118 55 E.		3044
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Q. NORTHWEST OF AUSTRALIA

[All of the reefs immediately off the northwestern coast of Australia lie on the continental shelf. The majority are within the 100 fathom line. Imperieuse Reef, Clerke Reef, Scott Reef and Cartier Islet lie outside the 100 fathom line, but are on the outer edge of the shelf. Despite this fact, they are included here because of their similarity to "atolls." Mermaid Reef, although of atoll form, has no dry land. Cocos-Keeling Islands are the only true atolls in this area.]

1.	Imperieuse Reef	17°36' S.	118°50' E.	[Sandy I., 8 ft.]	3420
2.	Clerke Reef	17 25 S.	119 20 E.	[" I., 8 ft.]	3420
3.	Scott Reef	14 05 S.	121 50 E.	[" I., 8 ft.]	3419
4.	Cartier Islet	12 32 S.	123 33 E.	[Small islet, 4 ft. on small reef]	3419
5.	Cocos-Keeling Islands Cocos atoll North Keeling atoll	12 10 S.	96 50 E.	[Two atolls]	3109

[Note: Pelsart [in Houtman's Abrolhos, 28°56' S., 113°59' E.] is not an atoll, but consists of islets in lagoon shape on the edge of the continental shelf.]

R. LACCADIVE ISLANDS [North to South] 1590

1.	Cherbaniani Reef Beleapani Reef	12 18 N.	71 54 E.	[2 sand cays]	
2.	Byramgore Reef Chereapani Reef	11 50 N.	71 54 E.	[No dry land areas ?]	
3.	Chetlat Island	11 42 N.	72 42 E.	[Single islet]	
4.	Bitra Reef	11 32 N.	72 10 E.	[Tree I., trees 55 ft.]	
5.	Kiltan Island	11 29 N.	73 00 E.	[Small islet]	
6.	Kardamat (Cardamum) I.	11 13 N.	72 47 E.	[Treetops 85 ft.]	
7.	Peremul Par	11 10 N.	72 04 E.	[Sand cay, 4 ft.]	
8.	Ameni (Amini) Island	11 07 N.	72 45 E.	[Islet and sand cay]	
9.	Aucutta or Agatti Island Kalputi I., Pirli I. Tinnagara I., Bunngara I.	10 51 N.	72 11 E.	[4 small islands; 80 ft. to treetops]	
10.	Androth Island	10 50 N.	73 41 E.	[Small, narrow islet]	
11.	Kavaratti Island	10 33 N.	72 38 E.	[Treetops 90 ft.]	
12.	Kalpeni Island Charia Island	10 05 N.	73 38 E.	[Treetops 84 ft.] [2.5 mi. to NNE]	
13.	Suheli Par	10 04 N.	72 17 E.	[Oval patch, 3 islets, palms 90 ft.]	

(Nine degree channel)

Key No.	Accepted Name (Alternative names)	Latitude ° , ° ,	Longitude ° , ° ,	Notes	H.O. Chart
(R. LACCADIVE Islands continued)					
14.	Minikoi or Minicoy (Eight degree channel)	8 30 N.	73 00 E.		1590
S. MALDIVE ISLANDS (Double line of atolls, north to south)					5661, 1591
1.	Ihvandiffulu atoll	7 02 N.	72 55 E.	[About 17 islets]	5661
2.	Tiladummati atoll (Tilla dou Matte) [N.part] Miladummadulu atoll [S.part] (Milla dou Madou)	6 15 N.	73 05 E.	[Over 130 islets and "rings"]	5661
3.	Malcolm or Makaenudu atoll	6 18 N.	72 35 E.	[3 small islets]	5661
4.	North Malosmadulu atoll (Moresly channel)	5 35 N.	72 55 E.	[80 islets & rings] [2 miles wide]	5661
5.	South Malosmadulu atoll (Mahlos Mahdoo) Northern part Southern part	5 20 N. 5 10 N.	72 58 E. 72 58 E.	[12 islets & rings] [62 islets & rings]	5661
6.	Horsburgh atoll	4 52 N.	72 53 E.	[4 islets on nearly continuous rim]	5661
7.	Fadiffolu atoll	5 25 N.	73 30 E.	[45 islets & rings]	5661
8.	Gaha Faro [Island]	4 45 N.	73 25 E.	[E. end small atoll]	5664
9.	Male atoll [Residence of Sultan and seat of government] (Wadu Channel)	4 25 N.	73 30 E.	[96 islets & rings] [2.3 mi. wide]	5664 5662
10.	South Male atoll	3 57 N.	73 25 E.	[31 circular reefs]	5662
11.	Toddu Island	4 25 N.	72 57 E.	[isolated islet]	
12.	Rasdu atoll	4 18 N.	72 58 E.	[3 islets, 2 reefs]	5662
13.	Ari atoll	3 50 N.	72 50 E.	[150 reef patches]	5662
14.	Nilandu (Nillandoo) atoll Northern part Southern part	3 13 N. 2 48 N.	72 55 E. 72 56 E.	[48 reef rings] [56 reef rings]	5662
15.	Walidu (Phaleedoo) atoll	3 30 N.	73 30 E.	[75 reef rings]	5662
16.	Wataru Reef	3 15 N.	73 26 E.	[2 small islets]	5662
17.	Mulaku (Moluque) atoll	3 00 N.	73 28 E.	[70 reef patches]	5662
18.	Kolomadulu atoll	2 23 N.	73 08 E.	[25 rings & islets]	5662
19.	Haddummati atoll (One and Half degree Channel)	1 55 N.	73 25 E.	[Isdu, Gang, and 3 other islets on nearly continuous reef]	5662 5663
20.	Suvadiya atoll (Huvalu, Suadiya)	0 30 N.	73 15 E.	[84 closely spaced patches]	5663
21.	Fua Malaku Island (Phoowa Moloku)	0 17 S.	73 26 E.	[Islet, fringing reef]	5663
22.	Addu atoll (Addoo)	0 38 S.	73 10 E.	[7 islets on 2 curved reef patches]	5663

Key No.	Accepted name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
T.	CHAGOS Archipelago	[A complex of atoll reefs, some with islets, others completely sunken rings.]			Br.3,4,3869
1.	Peros Banhos Ile de Coin	5 20 S.	71 50 E.	[33 islets] [settlement]	3869
2.	Salomon Islands Boddam Island			[pear-shaped atoll] [at S.point]	3867
3.	Nelsons Island	5 41 S.	72 20 E.	[on N.side of a sunken atoll]	3869
4.	Great Chagos Bank	[has the following three groups of islets:]			3869
	Three Brothers	6 10 S.	71 33 E.	[3 small islets]	
	Eagle Islets	6 10 S.	71 21 E.	[2 " "]	
	Danger Island	6 22 S.	71 16 E.	[40 ft. high.]	
5.	Egmont [atoll]			[6 small islets]	3869
6.	Diego Garcia	7 20 S.	72 25 E.	[wedge-shaped lagoon enclosed by land rim]	3868
U.	WESTERN INDIAN OCEAN				
1.	Cargados Carajos Shoals	16 30 S.	59 30 E.	[6 islands:]	3864
	Albatross, North, South, Siren, Pearl, Frigate				
2.	Coco Reef	16 25 to 16 50 S.		[6 islands:]	3864
	Ile Raphael, Avocare, Mapare, Verrange, Coco Is.			[2]	
3.	Agalega Islands	10 25 S.	56 40 E.	[2 islets]	3864
4.	Ile Tromelin (Tromelin I.)	15 62 S.	54 25 E.	[15 ft.]	1881,3864
	SEYCHELLES group	[Most of this group are high islands; scattered along a barrier-like reef are the following: (5 to 8)]			2809
5.	Bird Island (Ile Vasches de Mar)	3 43 S.	55 12 E.	[58 ft.]	3851
6.	Denis (Dennis) Island	3 48 S.	55 40 E.	[30 ft.]	2809
7.	Platte Island	5 55 S.	55 20 E.		2809
8.	Coetivy Island	7 06 S.	56 15 E.	[40 ft.]	2809
	AMIRANTE Islands	[9 to 20]			
9.	"Africa Islands"	4 52 S.	53 20 E.	[2 islets,10 ft.]	2809
10.	Eagle Island	5 08 S.	53 15 E.	[Treetops,50 ft.]	2809
11.	D'Arros Island	5 25 S.	53 15 E.	[Treetops 86 ft.]	3851
12.	St.Jospeh Islands	5 26 S.	53 20 E.	[Circular reef with:	3851
	Resource [40 ft.], Fourquet [40 ft.], St.Joseph [treetops 80 ft.], Benjamin [10 ft.], Cascassage (10 ft.], Poule [10 ft.] Pelican [20 ft.], Chien Islet [20 ft.]				
13.	Desroches Island (Amirante)	5 40 S.,	53 40 E.	[Treetops,120 ft.]	3851
14.	Poivre Islands	5 45 S.,	53 15 E.	[2 islets, 75 ft.]	3851
15.	Etoile Cay	5 54 S.,	53 15 E.	[15 ft.]	3851

Key No.	Accepted Name (Alternative names)	Latitude ° ' "	Longitude ° ' "	Notes	H.O. Chart
(U. WESTERN INDIAN OCEAN, continued)					
16.	Boudeuse Cay	6 05 S.	52 50 E.	[15 ft.]	2809, 3851
17.	Marie Louise Island	6 11 S.	53 09 E.	[Treetops 90 ft.]	2809
18.	Ile des Noeufs	6 15 S.	53 03 E.	[18 ft.]	2809
19.	Alphonse Island	7 01 S.	52 45 E.	[Inhabited]	2809
20.	[Atoll-like reef, center]	7 10 S.	52 45 E.	[2 islets:]	2809
	Bijoutier Island	7 04 S.	52 45 E.	[Coconut palms]	
	San Françoise Island	7 12 S.	52 45 E.		
21.	Farquhar group	10 10 S.	51 08 E.	[Elliptical reef with:]	3861
	North I., South I., Goelette I. and other small islets.				
22.	Cerf Islands Reef			[24 x 5 miles, with:]	3851
	Wizard Reef	8 50 S.	51 03 E.	[awash, rocks uncovered]	
	Providence Island	9 14 S.	51 02 E.	[50 ft., village]	
	St. Pierre Island	9 20 S.	50 43 E.	[40 ft., coconuts]	
	Cerf Island	9 32 S.	51 00 E.	[7 small islets]	
23.	Isles Glorieuses (Glorioso Islands)	11 33 S.	47 20 E.	[Reed, 10 mi. dia. BA. with:]	724
	Ile du Lise or Lys			[35 ft.]	
	Verte Rocks & South Rocks			[3 ft.]	
	Isle Glorieuse			[1 mi. square]	
24.	Astove Island	10 06 S.	47 45 E.	[45 ft.]	3861
25.	Cosmoledo group	9 42 S.	47 35 E.	[7 islets around	3861
	Menai [40 ft.], North Is. [2],			elliptical lagoon]	
	Polyte [35 ft.], Wizard [55 ft.], Pogoda [20 ft.], South [25 ft.]				
26.	Aldabra atoll	9 25 S.	46 22 E.	[Nearly continuous	3861
	West I. (Ile Picard)			land surrounds lagoon;	
	Polymnie I. [70 ft. clumps]			3 channels; 4 islets on	
	Middle (Malabar) I. [60 ft.]			rim, 2 in lagoon]	
	South I. [largest, 70 ft.]				
	Euphrates [Ile Esprit] [40 ft.]				
	Coconut I. [Ile Michel] [70 ft.]			[In the lagoon]	

V. CARIBBEAN Sea [Counterclockwise from north]

[Note: It has been stated that there are no true "atolls" in the Caribbean Sea or Gulf of Mexico; the following are coral or reef islands outside the 100 fathom line on the continental shelf.]

- Hogsty Reefs
Los Corrales 21 41 N. 73 49 W. [Reef-enclosed lagoon with 2 sand cays] 2805
- Mira-por-vos Islets 22 05 N. 74 30 W. [Kite-shaped shoal with cay and rocks] 2806
- Cay Sal Bank 24 - N. 80 - W. [Bank, 60x35 mi. cays around edge] 944, 1290
Cay Sal [30 ft.], Elbow Cay [30 ft.] 2624
Water Cays, Muertos Cays, Dog Rocks [30 ft.],
Damas Cays, Anguila Isles [40-50 ft.]

[On BANCO CAMPECHE, north of Yucatan, within 100 fathom line, but individually isolated, are the following, 4 to 8.]

- Arrecife Alacran 22 30 N. 89 42 W. [Elliptical reef, no marked lagoon, 5 islets] 966
(Alacran Reef) 1233, 1240

Key No.	Accepted name (Alternative names)	Latitude ° ,	Longitude ° ,	Notes	H.O. Chart
(V. CARIBBEAN Sea continued)					
5.	Cayo Arenas)Arebas Cay)	22 07 N.	91 24 W.	[2 reef patches, cays]	1233
6.	Cayo Nuevo	21 40 N.	92 10 W.		2056
7.	Los Triangulos Cayo Este [24 ft.], East and West	20 55 N.	92 13 W.	[2 reef patches, each with los cays]	1233
8.	Cayos Arcas (Arcas Cays)	20 12 W.	91 58 W.	[Reef with 3 cays, 21']	1234
9.	Chinchorro Bank (Banco Chinchorro) Turneffe Islands	18 35 N.	87 20 W.	[Nearly continuous reef, 3 cays, 56' treetops] [Not sufficiently surveyed to determine form]	1072
10.	Lighthouse Reef	17 20 N.	87 30 W.	[Atoll-like, 5 cays]	1120, 1498
11.	Glover Reef	16 50 N.	87 50 W.	[Sunken atoll-like; 5 small cays]	1120
12.	Swan Islands	17 25 N.	83 50 W.	[up to 60 ft.]	5170
13.	Caratasca Cays	15 56 N.	83 16 W.		5381
14.	Becerro Cay	15 55 N.	83 15 W.		5381
15.	Vivario Bank	15 33 N.	83 20 W.		5381
16.	Albuquerque Cays	12 10 N.	81 51 W.	[2 cays on shoal]	2077
17.	Courtown Cays	12 24 N.	81 28 W.	[3 cays on shoal]	2077
18.	Roncador Bank	13 32 N.	80 02 W.	[cay, 13 ft. on shoal surrounding lagoon]	1374
19.	Serrana Bank	14 22 N.	80 18 W.	[2 lagoons, 6 cays]	1374
20.	Quita Sueno Bank	14 20 N.	81 15 W.	[1 cay on bank]	945
21.	Serranilla Bank	15 50 N.	79 55 W.	[4 cays on shoal]	1489
22.	Bajo Nuevo	15 52 N.	78 39 W.	[2 atoll-like reefs, with 1 cay]	1488
23.	Pedro Bank	17 - N.	78 - W.	[4 cays; not atoll- like; 100x60 mi.]	5350
24.	Morant Cays	17 20 N.	76 00 W.		708
25.	Albatross Bank	17 40 N.	75 45 W.	[Cays ?]	708
26.	Islas des Aves or Aves Island	12 - N.	67 30 W.		6363
W. ATLANTIC OCEAN					
1.	Rocas Reef or Atol das Rocas	3 52 S.	33 49 E.	[Small atoll, with 2 islets] [135 miles NE of Cabo Calcanhar, Brazil]	537

ALPHABETICAL INDEX

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Anangai	J.29	Baars Island	P (note)
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Elizabeth Island	H.19, N.3	Francis Island	G.6
Elizabeth Reef	L (note)	Fraser	J.3
Ellice atoll	F.3	Frederick Reef	L.18
Ellice Islands	F	Freewill Islands	J.40
Elmore atoll	H.20	Frigate Island	U.1

Fua Mulaku Island	S.21	Heretua [Island]	B.15
Fugitive Island	C.2	Hermit Islands	N (note)
Funafuti	F.3	Hervey Islands	D.12
Furaarappu To	J.27	Hikueru Island	B.35
Furneaux Island	B.39	Hiti Island	B.52
Furukku To	J.28	Hog Island	J.19
Gaferut Island	J.26	Hogsty Reef	V.1
Gaha Faro [Island]	S.8	Hok	J.19
Gallows Reef	M'.5	Hokanhiui Reef	L.3
Gang Islet	S.19	Holt Island	B.48
Gardner Island	D.27	Honden Island	B.41
Gaspar Rico	H.15	Hopper Island	G.10
Gente Hermosa	D.21	Horsburgh atoll	S.6
Gilbert Islands	G	Hoten Rif	J.39
Gisser	P (note)	Hough	J.19
Glorieuses, Isles	U.23	Houtman's Abrolhos	Q (note)
Glorioso Islands	U.23	Howe Island	C.4
Gloucester Island	B.26	Howland Island	D.34
Gloucester, Duke of, Is.	B.13-15	Hudson Island	F.8
Glover Reef	V.11	Huiyao	J.22
Goelette Island	U.21	Hull Island	C.1, D.26
Good Hope Island	B.38	Humphrey Island	D.14
Goram	P (note)	Hunter Island	H.18
Gosong Boni	P.3	Huon Island, lagoon	L.8
Grand Duke Alexander I.	D.15	Huraarappu To	J.27
Great Chagos Bank	T.4	Hurd Island	G.1
Greenwich Islands	J.8	Hurukku To	J.28
Greig atoll	B.64	Huvadû atoll	S.20
Grimes Island	J.26	Ibbetson	H.4
Gulf of Mexico	V	Ifalik atoll	J.28
Gurimesu To	J.26	Ifalouk, Ifaluk	J.28
Gurinititi To	J.8	Ifelug, Ifeluk	J.28
Haddumati atoll	S.19	Ihvandiffulu atoll	S.1
Halcyon Island	I.1	Ile de Coin	T.1
Hall Island	G.11	Ile de Sable	C.7
Hall Islands	J.13	Ile des Noeufs	U.18
Hao Island	B.29	Ile du Lise, Lys	U.23
Haraiki Island	B.34	Ile Esprit	U.26
Hariri Island	B.26	Ile Michel	U.26
Harp Island	B.29	Ile Picard	U.26
Harvest	J.10	Ile Raphael	U.2
Haug	J.19	Ile Tromelin	U.4
Hauschauber	N.2	Ile Vaches de Mer	U.5
Hawaiian Islands	E	Imperieuse Reef	Q.1
Hayrick Islands	N.2	Independence Island	D.5
Hagemeister Island	B.66	Indian Ocean, Eastern	Q
Heina atoll	N.11	Indian Ocean, Western	U
Helato	J.24	Indonesia	P
Helen Reef	J.39	Isdu Islet	S.19
Henauke Island	B.41	Isles des Aves	V.26
Henderville Island	G.8	Iles Glorieuses	U.23
Heo Island	L.5	Iuripik	J.30
Herald Beacon Island	L.14	Jabwot Island	H.21
Herald Cays	L.25	Jaluit atoll	H.19
Hereheretue Island	B.16	Japan Fayu	J.14
Heren Sho	J.39	Jarvis Island	D.6

Jemo Island	H.9	Kunto Shoto	J.15
Jennings Island	D.21	Kuop atoll	J.15
Jervis Island	D.6	Kurateke Island	B.12
Joan de Nova	U.21	Kure Island	E.5
Johnston Island	D.35	Kuria Island	G.9
Johnston Islands	N.4	Kurru To	J.33
Kabeneylon	J.8	Kutusov, Kutusow	H.13
Kabia	P (note)	Kwajalein atoll	H.26
Kadogubi	J.38	Kwedjelin	H.26
Kajangle, Kajanguru	J.34b	Laars Island	P.13
Kakabia	P.(note)	Laccadive Islands	R
Kaledoepa, Karang	P.5	Lae atoll	H.24
Kaloe Kalukuang	P.14	Lagoon Island	B.23
Kalpeni Island	R.12	La Harpe Island	B.28
Kalputi Island	R.9	Lai atoll	H.24
Kalu Kalukuang	P.14	Lambert	H.22
Kalukuang, Kalu, Kaloe	P.14	Lamorsu	J.23
Kama Islands	J.30	Lamoliaur Ulu, Lamoliork	J.33
Kaniet Islands	N.9	Lamotrek atoll	J.23
Kapen-Mailang	J.8	Lamuniur	J.33
Kapingamarangi atoll	J.8	Lamureck, Lamurrec	J.23
Kapoposang Bali, Kg.	P.9	Lancier Island	B.24
Karang Kaledoepa	P.5	Laskar Island	E.2
Kardamat Island	R.6	Lassion Island	E.2
Karlshoff Island	B.62	Latei Tonga	K (note)
Kata	J.18	Latei Viti	K (note)
Katharine	H.25	Laysan Island	E.1
Katiu Island	B.50	Lazareff Island	B.75
Kaukura atoll	B.65	L'Echiquier	N.13
Kauehi Island	B.61	Le Leizour Island	L.7
Kavaratti Island	R.11	Leueneuwa	M.1
Kaven, Kawen	H.5	Lib Island	H.23
Kayangel Islands	J.34b	Lighthouse Reef	V.10
Kazuanguru	J.34b	Lihon Reef	L.21
Keeling atoll	Q.5	Likieb, Likiep atoll	H.8
Keen Reef	L.15	Liot Island	N.17
Kemins Island	D.27	Lip Island	H.23
Kenti Ole	P.5	Lise, Ile du	U.23
Kentschikow	H.26	Lisianski, Lisiansky I.	E.2
Kg. [Karang] (see 2nd word)		Little Makin Island	G.16
Kili Island	H.18	Little Paternoster Is.	P (note)
Kilinailau Islands	M.4	Livingston	J.16
Kiltan Island	R.5	Long Island	L.12
Kimisisima Shoto	J.15	Long Reef	M'.2
Kingman Reef	D.10a	Loop Island	L.12
King's Island	B.60	L'Orange Island	B.28
Kiri To	H.18	Lord Hood(s) Island	B.8
Knox Island	G.12	Lord Howe Island	C.4
Kodgubi	J.35	Lord Howe Islands	M.1
Koka, Karang	P.5	Lord North Island	J.38
Kolomadulu atoll	S.18	Losap atoll	J.11
Kornikoff Island	D.20	Los Corrales	V.1
Koutousoff Island	B.49	Los Martires	J.17
Kreis Reef	N (note)	Los Reyes	N (note)
Krusenstern Island	B.74	Los Triangulos	V.7
Kuezyerin To	H.26	Los Valientes	J.5

Lossop-Inseln, Louasaope	J.11	Maruroa Island	B.9
Louisiade Archipelago	M'	Marutea Island [2]	B.8,39
Low Islands	B	Mary, Mary Balcout Island	D.32
Loyalty Islands	L	Massachusetts Island	E.4
Luangia	M.1	Matahiva, Mataiwa Island	B.75
Luguen	J.18	Matelotas	J.33
Lukeisel	J.11	Matilda Island	B.9
Lukunor atoll	J.9b	Matthew Island	G.14
Lukunor-gruppe	J.9	Maturei-vavao	B.3
Lumuliur	J.33	Maty Island	N.20
Lütke Island	J.14,16	Maura Island	C.4
Lydia	H.26, J.20	Mbukatatanoa Reef	K (note)
Lynx Island	F.7	McAskill	J.1
Lys, Isle du	U.23	McKean Island	D.28
Macaskill	J.1	Meaty Mirang	P.2
Mackenzie Islands	J.32	Medjit, Mejit Island	H.11
Madjuro Island	H.3	Melbourne Island	B.3
Magdelaine Cays	L.26	Meliel	J.37
Mahlos Mahdoo	S.5	Mellish Reef	L.14
Maiana Island	G.11	Melville Island	B.35
Majuro atoll	H.3	Menai Island	U.25
Makaenudu atoll	S.3	Mendana Island	I.1
Makarama	J.8	Menschikoff	H.26
Makemo Island	B.49	Mereyon To	J.29
Makin Island	G.15,16	Merier, Merir Island	J.37
Makin Meang	G.16	Mermaid Reef	Q (note)
Malabar Island	U.26	Meziti To	H.11
Malcom atoll	S.3	Mezyuro To	H.3
Malden, Maldon Island	D.5	Miadi	H.11
Maldivé Islands	S	Michaeloff Island	K.2
Male atoll, Island	S.9	Michel, Ile	U.26
Maletin Island	N.16	Mid Islet	L.27
Maleelab, Maloelap atoll	H.5	Middle Island	U.26
Malosmadulu atolls	S.4,5	Middle Bellona Reef	L.11
Manahiki Island	D.14	Middlebrook Islands	E.4
Mangorongoro Island	D.13	Middleton Reef	L (note)
Manihi Island	B.71	Midway Islands	E.4
Manihiki Island	D.14	Milla dou Madou	S.2
Manra Island	D.25	Milladummadulu atoll	S.2
Manu Island	N.18	Mili, Mille, Milli atoll	H.1
Manuae Island	D.12	Minami Tori Shima	I.2
Manuhangi Island	B.27	Minerva Reefs	D.20 (note)
Mapare Island	U.2	Minicoy, Minikoi	R.14
Mapia atoll	J.40	Minto Island	B.4
Marakei I., Maraki I.	G.14	Mira-por-vos Islets	V.2
Marcus Island	I.2	Mire, Miri To	H.1
Margaret Island	B.13	Mitchell Island	D.18, F.2
Margaretta	H.26	Mobidie Island	C.4
Maria Island	B.2, C.1	Moearas Reef	P.15
Marie Louise Island	U.17	Moerenhout Island	B.2
Marion Reef	L.20	Mogal, Mokil atoll	J.2
Maroerappu To	H.5	Mokiru To	J.2
Marokau Island	B.32	Moller Island	B.30, E.1
Marqueen Islands	M.3	Moluque	S.17
Marshall Islands	H	Monteverde	J.7
Martha Island	A.3	Monteverdeson's group	J.7

Moore Isle	J.34b	Nevil Island	J.38
Mopelia, Mopihaa Islands	C.4	New Caledonia	L
Morane Island	B.1	New Hebrides	L
Morant Cays	V.24	New Nantucket Island	D.33
Moresly channel	S.4/5	New Year Island	H.11
Morileu	J.13a	New York Island	D.9
Mortlock Islands	J.9	Ngaruani Reef	J.34a
Mosley Islet	N.7	Ngatik atoll	J.5
Mototokke Shoto	J.9	Ngele-levu Island	K.7
Motu Iti, Motu One	C.3	Ngelu	J.33
Motutunga Island	B.54	Nggele-levu Lagoon	K.7
Mourileu	J.13a	Ngiul, Ngoli, Ngolii	J.33
Muaras Reef	P.15	Ngolog, Ngulu, Ngoly	J.33
Muertos Cay	V.3	Ngulu atoll	J.33
Mulaku atoll	S.17	Niambo Island	K.3
Mulgrave Island	H.1	Niau atoll	B.64
Murilo, Muriro Shoto	J.13a	Nigeri, Nihiru Island	B.40
Murray Islet	N.7	Nikumaroro	D.27
Musgrave	J.1	Nikunau Island	G.5
Musquillo	H.22	Nilandu, Nillandoo atoll	S.14
Myloradowitich Island	B.57	Ninigo atoll	N.13
Nager Islands	N.5	Ninigo group	N.11-17
Naiad	J.9a	Niulakita	F.1
Nairea atoll	B.73	Niutao Island	F.7
Nama Island	J.12	Noekori	P.1
Namo	H.22	Noekwendi	P (note)
Namochikku To	J.23	Noeufs, Ile des	U.18
Namoliaour	J.25	Nokanhui Reef	L.3
Namolipiafane	J.13b	Nomoi Islands	J.9
Namolotou	J.9a	Nomwin atoll	J.13b
Namoluk atoll	J.10	Nonouti, Nonuti Island	G.7
Namonefeng	J.9b	Nororutu Island	C.1
Namonuito atoll	J.16	North Bampton Reef	L.9
Namorik atoll	H.17	North Cay	L.27(etc.)
Namorukku To	J.10	North Island	U.1,3,9,21
Namotikku To	J.23	North Islands	U.25
Namouin-atoll	J.13b	Northeast Cay	L.25
Namouttek	J.23	Northern Cook Islands	D
Namu atoll	H.22	North Keeling	Q.5
Namurikku To	H.17	North Malosmadulu	S.4
Namurrek	J.23	North Marutea Island	B.39
Nanuuin Shoto	J.13b	Northwest Pacific	I
Nanomana Island	F.8	Nuevo, Cayo	H.6
Nanomea Island	F.9	Nugoru To	J.7
Nanouki Island	G.8	Nuguria Islands	M.5
Nanuku Reef	K.5	Nui Island	F.6
Nanumanga Island	F.8	Nukufetau	F.4
Nanumea Island	F.9	Nukulaelae	F.2
Napuka Island	B.44	Nukulailai	F.2,K.5
Narcissus Island	B.19	Nukulevu Island	K.5
Nassau Island	D.18	Nukumanu group	M.2
Natikku To	J.5	Nukumbalate Island	K.6
Nelsons Island	T.3	Nukumbasanga I., Reef	K.6
Nemu	H.22	Nukunau Island	G.5
Nengonengo Island	B.28	Nukunono Island	D.23
Netherland Island	F.6	Nukuoro atoll	J.7

Nukusemanu Island	K.5	Pearl Island	U.1
Nukutaveke Island	B.21	Pearl and Hermes Reef	E.3
Nukutolu	K (note)	Pedder Island	H.2
Nukutipipi Island	B.13	Pedro Bank	V.23
Nurakita Island	F.1	Pelelap, Pelelap	J.1
Oaitupu Island	F.5	Pelican Islet	U.12
Oatafu Island	D.24	Pell Island	E.2
Observatory Cay	L.21(etc.)	Pelleluch atoll	N.12
Ocean Island	E.5	Pelleluhu	N.12
Odia atoll	H.20	Pelsart	Q (note)
Odjia, Odtia	H.7	Penrhyn Island	D.13
Oeno Island	A.3	Peremul Par	R.7
Oleai, Oleei, Olie	J.29	Peros Banhos	T.1
Olimarao, Olimanau Is.	J.25	Peru Island	G.6
Ollap	J.17	Pescadore Islands	H.29
Olosenga, Olosega	D.21	Pescadores	J.8
Olutei, Olutel	J.24	Petrie Reef	L.6
Onata Islands	J.40	Phaleedoo	S.15
One and Half Degree Chan.	S.19/20	Phillip Island	J.31
Onomarai	J.25	Phillips Island	B.49
Onon	J.16	Phoebe Island	D.33
Onotoa Island	G.3	Phoenix Island	D.30
Oncun, Onoune	J.16	Phoenix Islands	D.25-32
Ontong Java	M.1	Phoowa Moloku	S.21
Oraluk	J.6	Picard, Ile	U.26
Ormsbee	P (note)	Pigali	J.20
Oroluk atoll	J.6	Pigerotto To, Pigoualao	J.20
Orona Island	D.26	Pikaru To	H.14
Ororu Shoto	J.16	Pikela, Pikelot Island	J.20
Ororukku To	J.6	Pikiram	J.8
Osnaburgh Island	B.9	Pinaki Island	B.20
Otakootaia	D.11	Pingarappu To	J.1
Otocho Island	B.45	Pingelap, Pingoulap	J.1
Otori Jima	I.1	Pirli Island	R.9
Ottilien Reefs	N (note)	Pitts Island	G.16
Ouleai	J.29	Platte Island	U.7
Ouluthy	J.32	Poeloe Sabalana	P.11
Oura Island	B.70	Pogoda Island	U.25
Padaido Islands	P (note)	Poivre Islands	U.14
Pagenema	J.4	Pokaakku To	H.15
Paget Cay	L.20	Pokak atoll	H.15
Pak	N (note)	Pokela	J.20
Pakin atoll	J.4	Pollap	J.17
Palawat Islands	N.7	Poloae, Pololat, Polowat	J.18
Palmerston Island	D.16	Polymmie Island	U.26
Palmyra Island	D.10	Polyte Island	U.25
Paolo	J.36	Postiljon Islands	P.10,11
Papialou Islands	N.2	Poule Islet	U.12
Papakena Island	B.11	Poulouote	J.18
Paraoa Island	B.26	Pourappu To	J.17
Parece Vela	I.3	Prince William Henry I.	B.28
Pasir Tengah	P (note)	Prospect Island	D.9
Passage Island	L.12	Providence Island	H.33, U.22
Paternoster Islands	P.9	Pukapuka (Danger Islands)	D.19
Paternoster, Little, Is.	P (note)	Pukapuka Island	B.41
Paumotu Islands	B	Pukaruha Island	B.18
Peacock Island	B.72	Pul	J.36

Pulap, Pullop atoll	J.17	Rukute To	J.14
Pulo Anna Islands	J.36	Rurick Island	B.67
Pulo Marier	J.37	Sabalana Islands	P.11
Puluot	J.18	Sabaroe Island	P.11
Pulusuk Island	J.19	Sabben Islands	N.6
Puluwat atoll	J.18	Sable Isle de	C.7, L.1
Pur	J.36	Sadapur	P.8
Purdy Islands	N.5	Sae Islands	N.10
Puru Anna	J.36	Saliloes	P.9
Puttep	J.17	St. Andrew Island	J.35
Pyghelia	J.20	St. Andrew Islands	N (note)
Quatro Coronados	B.14	St. Augustine Island	F.9
Queen Charlotte Island	B.21	St. David Islands	J.40
Quiros Island	D.21	St. Josph Islands	U.12
Quita Suens Bank	V.20	St. Paul Island	B.16
Rae To	H.24	St. Pierre Island	U.22
Rahiroa atoll	B.73	St. Quentin Island	B.34
Rakahanga Island	D.15	St. Simeon Island	B.37
Ralik chain	H.16-33	Saken Island	B.50
Rangiroa Island	B.73	Sal, Cay	V.3
Raphael, Ile	U.2	Salomon Islands	T.2
Raraka Island	B.59	Sama "group"	N.14
Rarolia Island	B.47	Samarang Island	D.10
Rasdu atoll	S.12	Samoa, American	D.20, 21
Ratak chain	H.1-15	Samusamu Island	N.15
Ravahere Island	B.31	San Andreas	J.35
Raven group	J.5	San Bartolome	J.19
Reao Island	B.17	Sands Island	C.1
Redlick Islet	M'.3	Sandy Islet	Q.1, 2, 3
Reef Islands	L.1	San Francisco Island	I.1
Reid Island	B.51	San Francoise Island	U.20
Reid Reef	K (note)	San Miguel Archangel	B.15
Reirson Island	D.15	San Miguel Islands	N (note)
Reitoru Island	B.33	Sanna Island	L.1
Rekareka Island	B.38	San Narciso [Island]	B.19
Remp	J.16	San Pablo Island	B.16
Renard Island	L.9	San Rafael	J.12, N.1
Resolution Island	B.37	Saoedjoeng	P.9
Resource Islet	U.12	Saok	M.19
Rikieppu To	H.8	Sapoeka, Sapuka Islands	P.10
Rimski-Korsakoff Islands	H.30	Saraon, Sarol	J.31
Romanzoff Island	B.68, H.7	Sasaon, Satahual	J.21
Romanzow, Romanzov	H.7	Sataoan	J.9c
Roncador	M (note)	Sataual, Satavan	J.21
Roncador Bank (Cay)	V.18	Satawal Island	J.21
Rocas Reef	W.1	Satawan atoll	J.9c
Rongelab, Rongelap atoll	H.30	Satawan Island	J.21
Rongerik atoll	H.29	Sataon	J.9c
Rongirikku To	H.29	Satoenggoel, Karang	P.9
Rongorappu To	H.30	Satouwan	J.9c
Rose atoll, Island	D.20	Satowal, Satowalairak	J.21
Rosoppu To	J.11	Satuwal	J.21
Ross Islands	H.22	Saugk	J.19
Rotcher Island	G.2	Saumarez Reefs	L.19
Rowa Island	L.1	Sauugk	J.19
Royalist Island, Is.	J.11, 15	Schanz atoll	H.27
Rukunoru To	J.9b	Scheug, Schoog, Schoug	J.19

Scilly Islands	C.5	Syukku To	J.19
Scott Reef	Q.3	Tabiteuea Island	G.4
Searle Island	B.18	Taenga Island	B.48
Second Cay	L.20	Tagula Island	M' (note)
Sepper Island	F.7	Tahanea Island	B.55
Sermata Islands	P.2	Taiaro Island	B.60
Serrana Bank	V.19	Tainimbeka	K.7
Serranilla Bank	V.21	Taka atoll	H.12
Seteocel, Setoan	J.21	Taka Boné Raté	P.6
Seven Islands	J.5	Taka Garlarang	P.7
Seychelles group	U.5-8	Takapoto Island	B.70
Sheburne Reef	N (note)	Takaroa Island	B.69
Shukku To	J.19	Takume Island	B.46
Sibutu Islands	P (note)	Takutea Island	D.11
Simonoff Island	K.1	Tamana Island	G.2
Siren Island	U.1	Tamatam, Tametam	J.17
Six Islands	T.5	Tampoang	P.9
Skiddy	J.10	Tanu	M.3
Smyth Island	H.15	Taongi Island	H.15
Socu	J.19	Tapeteuea Island	G.4
Soemanga Island	P.11	Tapuaerangi	D.8
Sog	J.19	Taputa Island	B.70
Solomon Islands, N.of	M	Taputeuea Island	G.4
Sonesor, Songosor	J.35	Tarawa Island	G.12
Sonsol, Sonsonorol	J.35	Taritari Island	G.15
Sonsorol Islands	J.35	Tasman Islands	M.2
Sonsoru To	J.35	Tatakoto Island	B.19
Socughe	J.19	Tauere Island	B.37
Sophia Island	F.1	Taulalia Island	K.7
Sorol atoll, Sororu To	J.31	Tchigschagoff Island	B.55
Soug, Souk	J.19	Teke To	H.12
South Bellona Reef	L.10	Tekokota Island	B.36
Southeast Bampton Reef	L.9	Teku Island	B.14
South Island	U.3,9,21,25,26	Tematangi Island	B.10
South Male atoll	S.10	Temetem	J.17
South Malosmadulu	S.5	Temo	H.9
South Marutea Island	B.8	Tenararo Island	B.6
South Rocks	U.23	Tenarunga Island	B.4
Southwest Islet	L.24,25	Tengah, Pasir	P (note)
Souworoff Islands	D.17	Tepoto Island	B.45,53
Sove	J.19	Tetuaroa Island	C.2
Speiden Island	F.7	Thornton Island	D.1
Starbuck Island	D.4	Thousand Islands	P (note)
Stavers Island	D.3	Three Brothers	T.4
Suadiva	S.20	Thrum Cap	B.24
Suheli Par	R.13	Tiemo To	H.9
Sumasuma	N.15	Tilla dou Matte	S.2
Suprise Island	L.7	Tiger, Tijger Islands	P.6
Suvadiva atoll	S.20	Tikahau Island	B.74
Suvarov, Suwarow	H.12	Tikei Island	B.68
Suvarov, Suwaroff Is.	D.17	Tiladummati atoll	S.2
Suwarrow Islands	D.17	Timo	H.9
Swains Island	D.21	Timoe Island	A.4
Swallow Island	D.32	Tindal	H.10
Swan Island	V.12	Tinnagara Island	R.9
Sydenham Island	G.7	Tiokea atoll	B.69
Sydney Island	D.25	Toau Island	B.63

Tobi Island	J.38	Verte Rocks	U.23
Toddu Island	S.11	Vincennes Island	B.61
Toekang Besi Islands	P.5	Vivario Bank	N.15
Togobei	J.38	Vliegen atoll	B.73
Togran Islands	P (note)	Volunteer Island	D.4,6
Tokelau Islands	D 22-24	Vostock, Vostok Island	D.3
Tokobe	J.38	Wadu Channel	S.9/10
Tomini, Gulf of	P (note)	Wailangilala Island	K.4
Tong Islands	N.1	Wain Island	N.16
Tongareva Island	D.13	Wake Island, Wakes	I.1
Totiaroa Island	C.2	Warren Hastings	J.37
Tracy Island	F.5	Washington Island	D.9
Traversey	H.4	Wataru Reef	S.16
Tregrosse Islets	L.23	Water Cays	V.3
Triangulos	V.7	Waterlandt Island	B.71
Tromelin Island	U.4	Watoe, Watu	P (note)
Truk [not an atoll]	J.15	Watts	H.10
Tschitschagoff	H.6	Wellington Island	J.2
Tuamotu archipelago	B	Western Indian Ocean	U
Tuanake Island	B.51	Western Islets	N.8
Tubai Island	C.3	West Faiu, Fayu Island	J.22
Tucker	J.21	West Indies	V
Tukang Besi	P.5	West Island	U.26
Tureia Island	B.11	Whirlwind Reefs	N (note)
Turneffe Islands	V.9	Whitsunday Island	B.20
Tuvuna-i-ra	K.2	William the Fourth	J.3
Tuvuna-i-tholo	K.1	Willis Islets	L.27
Udjae	H.25	Wilsons Island	B.71
Udjelang	H.33	Wittgenstein Island	B.58
Ueito	J.16	Wizard Island	U.25
Ujae atoll	H.25	Wizard Reef	U.22
Ujelang atoll	H.33	Wolchonsky Island	B.46
Ulea, Uleai, Ulie	J.29	Wolea, Woleai atoll	J.29
Ulithi atoll, Uluthi	J.32	Wolkonsky Island	B.46
Umaitia Island	C.2	Woodle Island	G.9
Union Islands [Tokelau]	D.22-24	Worth Island	D.34
Uotto To	H.27	Wostock Island	D.3
Ura atoll	B.70	Wotho atoll	H.27
Urushi To	J.32	Wotje atoll, Wotsch	H.7
Utirik atoll,	H.13	Wottho Inseln, Wotto To	H.27
Utorokku To	H.13	Wozzie To	H.7
Uvea atoll	L.4	Wreck Reef	L.17
Uziran To	H.33	Wul, Wull	J.36
Uzyae To	H.25	Wuwulu Island	N.20
Vaches de Mer, Ile	U.5	Wytoohee Island	B.44
Vahanga Island	B.5	Yaruto To	H.19
Vahitahi Island	B.23	Yermaloff Island	B.48
Vairaatea Island	B.22	Yaluto	J.24
Vaitupu Island	F.5	York, Duke of, Island	D.24
Vanavana Island	B.12	Yoropie, Yorupikku To	J.30
Vanua Masi	K (note)	Yuripik	J.30
Vataua Island	K.8	Zandbuis Banks	P.8
Vekai Rock	K (note)	Zaraol	J.31
Verrange Island	U.2	Zyabatto To	H.21

ATOLL RESEARCH BULLETIN

No. 29

Health Report on Kapingamarangi

- Part I A Health Survey of Kapingamarangi, 1950
- Part II A Parasitologic Survey of Kapingamarangi, 1950
- Part III Blood Groups of the Kapingas, November 1950

by Ralph E. Miller

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Health Report on Kapingamarangi

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Hanover, New Hampshire

INTRODUCTION

This report covers field work carried out from June to December 1950 and is a study of the health beliefs and practices of the atoll dwellers of Kapingamarangi. The research was carried out by the author as a special project under the SIM (Scientific Investigation of Micronesia) program of the Pacific Science Board of the National Research Council. Generous support was given to this project by the Office of Naval Research, the Pacific Science Board, the Office of Island Governments, Office of the Chief of Naval Operations, Department of the Navy and by the Civil Administration Units in the Trust Territory. The results of the survey are submitted in three parts, consisting of the Health Survey of Kapingamarangi as Part I, A Parasitologic Survey of Kapingamarangi as Part II, and Blood Groups of the Kapingas as Part III.

The author was completely dependent upon the leader of the expedition, Dr. Kenneth P. Emory, for background material, orientation and interpreting, without which the attempt to survey would have been fruitless.

PART I

A HEALTH SURVEY OF KAPINGAMARANGI, 1950

General Description of the Atoll

Kapingamarangi atoll is situated just north of the equator at 155°30' degrees east longitude. It is a typical "low atoll" with the islands scattered closely along the eastern arc of the oval coral reef. There is one deep opening through the reef on the southwest where a narrow, tortuous passage will admit only small craft with ease.

The south easterly trade winds provide a nearly constant cooling breeze. In contrast to the islands to the north, rainfall is not abundant. Nearly every year sees a period of water scarcity when coconuts are used as the standard beverage. Dug wells are used for wash water. The occasional rainy periods provide enough water to store, for the greater part of the year, in cisterns above ground. Typical trade wind showers permit verdant plant growth. The annual rainfall is reported as 80 inches.

Temperature varies slightly, the coldest periods being during the rare overcast periods of rainy days when the temperature reaches 75° degrees. The warmest days occur when the low tide permits the exposed reef eastward of the islands to be heated by the midday sun. Islands close to the eastern reef edge are noticeably cooler than those separated by a wider band of reef from the cooling overwater breeze.

The tides rise once in the twenty-four hour period to about 3 feet above mean low and once during the period to 2 feet above mean low. The extreme low follows the extreme high. Only the extreme low tide permits exposure of the reef for a long enough period to permit noticeable temperature change inland. The usual daily temperature is 80° at night and 90° in the day, reaching the maximum at noon. Deviation from this daily cycle is very rare, and one day is so like another that no thought need be given to "dressing for the weather" or for the time of day.

Tidal current is, with rare exceptions, from easterly to westerly between the islands, that is, from ocean to lagoon along the island portion of the reef. There is a reversal for a short period of each tide through the pass. The current varies in strength with the time of tide and the wind velocity and very rarely with wind direction. The almost constant surf from the east has to be interrupted to cause a reversal of the current flowing by the islands. Violent storms are rare, the only one within memory being one of three days in 1947 when the wind was from the west during the entire storm.

The soil of the islets is a thin layer of coral gravel and sand mixed with leaf mold on a base of conglomerate slab of the raised reef type. The average level is about ten feet above mean sea level. In areas where large excavations have been made for taro swamps, coral rock and sand from

pandanus sail and HAU cloth. The cloth kilt has replaced the HAU kilt for daily wear and whenever available for special occasions trousers and shirts are worn by the men and long dresses by the women. A few men have shoes which are worn for dress occasions. Use of clothing of temperate climate type and of the cloth sail have prompted the importation of a few sewing machines (German period).

Sheet metal strips are used instead of thatch on a few roofs and for rainwater catch areas adjacent to concrete cisterns. Fish lines and nets are largely imported twine, though the largest nets are made from coconut fiber and cannot be duplicated by imported material. The metal fishhook has entirely replaced the shell and wooden variety and every fisherman prefers the glass and wood or glass and plastic diving goggles to the less efficient coconut oil-slick surface.

Nearly every household has at least one metal cooking utensil and there are a few eating implements.

Despite the modern importations, at times advantageous and at times of questionable value, the culture is essentially that of an isolated, primitive people. The daily routine of the women is the dawn bath and toilet in the tidecurrent, the opening of the ground-oven for morning food, forenoon gathering and preparation of food from plant and tree or cultivating of taro, the afternoon cooking and cleaning of fish, the late afternoon bath at the time clothes are washed, the evening meal after the family is reunited from trips to outer islands or fishing. Such routine is kept from monotony by mat weaving and basket making at odd moments or by groups of families working at preserving foods for out of season use. The trips to outlying islands on special occasions provide an element of recreation. There is this element in most of the daily tasks. None is carried to the point of fatigue and the spirit of play is seen in every occupation.

Men are concerned with building houses, canoes and shelters and with making the gear and equipment for such building and for fishing. The work is done usually in groups where there is mild competition of skill and exchange of tasks resulting in much fun and little fatigue. There are masters of each skill who take their acknowledged places as leaders.

Recreation, as such, is chiefly the play of children and, on Sundays, since work has become tabu by decree of the church, card playing by all age groups.

As might be expected in such a placid environment which is rarely unkind, there is little to cause nervous strain. An occasional crying child gives evidence of the frustrations of infancy. Rarely are these frustrations evident beyond infancy, and then are seen in the rare maladjusted household. A few of the populace have fear of disease and a few are over-concerned about their personal health evidenced by disproportionate apprehension about mild symptoms. Most, however, are happy, completely adjusted, with little thought for the future beyond a food supply.

The family units of this society are tied together by church meetings and by the frequent meetings for carrying on government affairs by the men. These serve to accept or reject publicly the proposals that have been discussed and usually settled in the daily informal meetings in the men's house and other work shops. Public announcements are as likely to be made at church gatherings as at the government meetings, and with equal weight.

This environment appears especially kind to children. They have few restrictions. For their first few years they are unhampered by clothing of any kind. Family discipline is so mild and casual as to appear like neglect. The children are as at home in the water as on land. They handle canoes with ease at an early age and a load of five captained by a ten year old is a not uncommon sight. The strongest, and apparently most effective admonition is a loud "sh-h-h!"

Youth is as unhampered. Boys or girls are seen in separate groups during the day but after sunset especially on moonlight nights canoe loads of mixed parties are off to outer islands or singing and dancing on the beach. There is apparently complete freedom of sex play and no stigma attached to premarital pregnancy or childbirth. An unknown father is in no way a handicap for such offspring. They are adopted and have the status of the mother. A single marriage partner is the rule but exceptions are noted and the household of a sterile marriage may be blessed by the offspring of a mutually acceptable partner to replace temporarily the unfruitful one.

The people are governed by a chief who has two assistant chiefs, one for Touhou islet and one for Werua islet. The ancient priesthood has been partly replaced by the Christian church. The position of magician or medicine man was one of importance with grave responsibilities and considerable authority. There is no one quite comparable in the present organization.

The administrative officers, school teacher and a medical aide receive salaries from the United States Civil Administration.

Order is maintained without visible restraints. Public opinion is all powerful, occasionally overruled by the chief, but at the risk of his chiefship.

The men and women take their positions of adult responsibility only after organizing a household of their own including at least one child, their own or adopted. The position is of full responsibility even then only if the work of the adults is considered as contributing to group welfare. Youths of both sexes are not compelled or even urged to work. The male takes full advantage of this, and for a certain period, comparable to the highschool and early college age, the boys are set apart from this otherwise industrious society. They loaf, sing, dance, are pampered by their mothers, are well fed and wear the gaudiest SERU the family can afford. They are even organized against work and exert their own public opinion against the occasionally ambitious youth. This period passes, and generally, without harm. A few carry the attitude on into their own adult household.

The girls early learn their task of being the burden bearers, and in youth do most of the household work, including care of younger children.

Sanitation

The sanitation of Kapingamarangi is of the natural type due to tide, sun, wind and rain. Man has altered his environment slightly, in part advantageously and in part with some hazards to health. When the alteration has favored health that aspect of the change has been a by-product and not the direct result of an attempt at more healthful conditions. There has not been, and is not now, any comprehension of the spread of disease from man to man or from animal to man.

Personal cleanliness is notable but not universal and there is a strong suspicion that its prevalence is induced by the desire to avoid attracting flies. The sea is ever present and easily accessible. Bathing in it is a daily activity of practically everyone. Pools on the reef reach 100 degrees F. in the midday sun and are a favorite bathing place. Prolonged soaking of clothing in the tide current is a favorite cleansing method and the nearest they ever come to sterilization.

Within the family circle personal contact is intimate and frequent. It starts before the first breath of life as the delivered infant has its mouth and nose aspirated by the application of the attendant's mouth and tongue. The infant is cared for by every member of the family, young and old. Some infant food is prechewed. All are served at the family table by the only common eating implement, the hands. Though food is ideally aseptic when removed from the ground oven in its tight containers, thereafter it is handled without regard for sanitation, unless it is to be kept for a later meal. It has been learned that food left intact in its wrapping after cooking will not spoil as rapidly as opened food, and that re cooking will prevent spoiling for many hours, but this experience has not been transferred to the use of heat to clean clothes, mats, sheets or blankets, towels or wound dressings.

Handkerchiefs are an affectation. Fingers are the acceptable substitute. Spitting is common, a gesture of slight nervousness.

Disposal.

The common toilet is the reef, covered or uncovered by sea. At times children consider that the general direction of the designated spot on the reef satisfies the convention, and many an adult contaminates areas of the reef close to a play area for children, a sand beach of which will be smeared by the drift of the next high tide. Even the effluvia of the several over-water (except during low tide) toilets is swept ashore either directly or by the swift current about the end of the islands into the lagoon. This is

preserved from severe contamination in the backeddy of the lagoon shore by dilution and speeding of the biologic cycle by the abundant sea life.

Refuse disposal areas are those requiring fill because of erosion or because mulch is desired for planting. The value of compost is known and banana and coconut plantings are made on compost pits in which vegetable refuse has been accumulating for months. The grounds generally are kept quite free from refuse. There is a daily morning "policing" of grounds when women and children pick up all fallen leaves and such refuse as the men and boys have thrown down anywhere. The houses do not accumulate refuse. All the cooking is done in or near the cook house, which is usually several feet, at least from the dwelling. Preparing of food and eating is generally out of doors. The times when indoor eating is necessary are rare. Under these circumstances scraps and bones are thrown out through the open sides of the house. Feet are washed before entrance onto matting portions of the floors.

There are weekly cleanup days and, periodically, days for burning stumps and refuse heaps along the high tide mark. A common type of refuse that appears difficult to control is ripe breadfruit falling at the peak of the season. Chewed pandanus keys are discarded without discretion.

The lagoon is the repository of all refuse except that put in compost pits for later tree planting. It is apparent that anything thrown or drifted into the lagoon is considered completely and finally disposed of. Baskets of miscellaneous refuse are dumped into the lagoon among groups of swimmers. People living along the lagoon shore wade into the water and use this universal toilet without regard for wind or tide. The currents of the back eddy that is fairly constant at each end of the islands form a sort of cess pool used for evening bathing by all and for fishing by small boys. The lagoon shore is a scene of constant activity, clothes washing, preparing coconut husk fiber for rope making, bathing, swimming, cleaning fish, loading and unloading canoes. All refuse remains where dropped in this shallow shore area until the next tide brings about a redistribution and dilution. Despite the dilution this remains a constantly contaminated area through which the populace (and visitors, until a pier was completed recently) wade or swim without a thought that it is any less pure than the open sea or rapidly flowing current between the islets. The same situation prevails at the common landing areas of the outer islands.

Residences and traffic are much more widely scattered at Werua and Taringa and their waterfronts are noticeably cleaner.

Food

The staples of the diet are taro, PURAKA, and coconut with fish as an almost constant accompaniment as are breadfruit and pandanus in season. The three variables, fish, breadfruit and pandanus are preserved (dried) in times of plenty but the supplies are insufficient to sustain the population for very long without the staple components. Breadfruit trees of three varieties are now well established and this item of food is approaching

the constancy of taro and coconuts. The varieties vary in maturing times and in duration of season but all are affected by drought. The oldest grown here and known as the Kapingamarangi variety matures in two months and bears for three months. The Nukuoro variety bears for a month then matures a new crop in one month. These two varieties of fruit contain large seeds which are edible when cooked. The third variety brought in from Ponape has been established too short a time to be certain of its season here, however it is different from the other two, maturing either two or three crops a year. This variety is without edible seeds, and does not lend itself to preservation by drying as do the other two.

Pigs, chickens, bananas and papayas are produced in too small quantity to contribute much to the diet and are considered as luxuries.

In times of drought taro, PURAKA, and coconut and fish may be the only supplies that persist and the coconuts are fewer and smaller. The taro is much smaller during these dry periods. The PURAKA does much better in the dry times and tends to overgrow the taro.

One famine has been recorded (1915 to 1917) when there was no rain for two years. Over fifty people died and the famine was aggravated by imposed rules restricting coconuts to copra production, denying their use for food. There were insufficient canoes during this same period reducing the amount of fish available.

Diet

Taro is cooked in coconut cream or grated coconut. This form of food accounts for the greater part of the use of coconuts as food. The soft pulp of drinking nuts is eaten but recognized as having little food value so far as sustaining activity is concerned. Pandanus is eaten, either raw or boiled, by chewing the soft part of the key. Flour is made for storage by pulverising baked pandanus pulp cakes. The flour is later eaten mixed with water as a porridge.

Fish is usually baked in leaf wrappings but some is eaten raw during its preparation and cleaning or may be served raw. The raw liver is relished by fishermen, and the liver allowed to remain within some varieties for cooking. The visible fat of fish and eels is a choice item of diet. Much variety is achieved in the diet, and possible additions of food value, by varying the leaf wrappings. Such additions are the only condiments beside the generally used coconut cream. No salt is used in cooking or during the meal. Salt is now used for preserving fish when the slices receive a slight coating of salt preliminary to drying in the sun.

Strong evidence of the adequacy of the diet is the condition of the residents who are robust, energetic, active, industrious and happy. No instance of malnutrition or obvious vitamin lack was noted. Their own studied analysis of what these people need to survive the most difficult times yields the answer that fish hooks and twine for the finer nets would see them through, because all other essentials of life are present or can be secured if they can maintain a sufficient supply of food fish.

The abundant varied food supply compensates for some items of the diet which have limited direct food value such as the fiber component of coconut husk (young nuts) and pandanus. During the pandanus season the faeces of children and some adults consist of a mass of such fiber. In any season when there is a decrease of standard items the husk of young coconuts is consumed in quantity for its slight sugar content. Both sources of fiber yield a fecal mass of such size and consistency as to be alarming. It may be that one of the unheralded virtues of the coconut alleviates the possible hazard of fecal impaction. The unaltered oil of the raw (and perhaps cooked) coconut is found in nearly all faeces specimens and in quantity in many. The oil is apparently a relatively bland lubricant. However this oil consists of a lost element of considerable amount from the theoretical quantity of available caloric content of the coconut. In quantity, the cooked oil is a cathartic of some violence. The pandanus oil is likewise found unaltered in the faeces. The assimilability of both these oils requires investigation, if not already studied.

Another food item used in quantity at certain times and as a small component of the diet throughout the breadfruit season is breadfruit seeds. Each fruit of the two seed-containing varieties contains from 10 to 30 seeds varying from 1 cm. to 1.5 cm. in diameter. Removal of the thin soft shell yields a kernel with the flavor of boiled chestnuts. The food value of this seed must be considerable. It takes the place of fish or meat in the dietary during fish shortage and immediately following the peak of the breadfruit season when the large quantity of seeds removed from the fruits prepared for drying are stored for a short time and then consumed in quantity as boiled or roasted nuts.

Rice is used at feasts. It has not been adopted as a staple of diet because of cost and availability of other food. In times of scarcity it is welcomed. Many families have a pot used especially for boiling rice. The leaders recognize that rice cannot replace items of the regular diet without interfering with the stability of supply. Coffee and sugar are luxuries, available to a few.

Water Supply

Formerly the water supply was from dug wells in the villages of Touhou and Werua and on the margins of the taro swamps. The water level in these wells rises and falls with the tide. The water is brackish in the village wells, precipitating much of the soap before suds are obtained. The concrete cisterns and metal strip catch areas, introduced by the Japanese, provide storage for months of use. This rain water is augmented by a store in metal drums filled from the same catch areas and from natural catchments such as coconut trees.

The wells are still the source of wash water except in times of abundance of rain water. It is stated that yearly there is some time when rainwater is scarce and, periodically, about once a generation, a prolonged drought. A survey of the cisterns indicates there is sufficient capacity to last two months. (See chart I).

Chart I

TOTAL NUMBER OF TANKS	27
TOTAL CAPACITY cubic feet	4800
USABLE TANKS	21
USABLE CAPACITY cubic feet	3700
TOTAL CATCH AREA USED	3800
Four large tanks CAPACITY	1500
Four large tanks CATCH AREA	1300

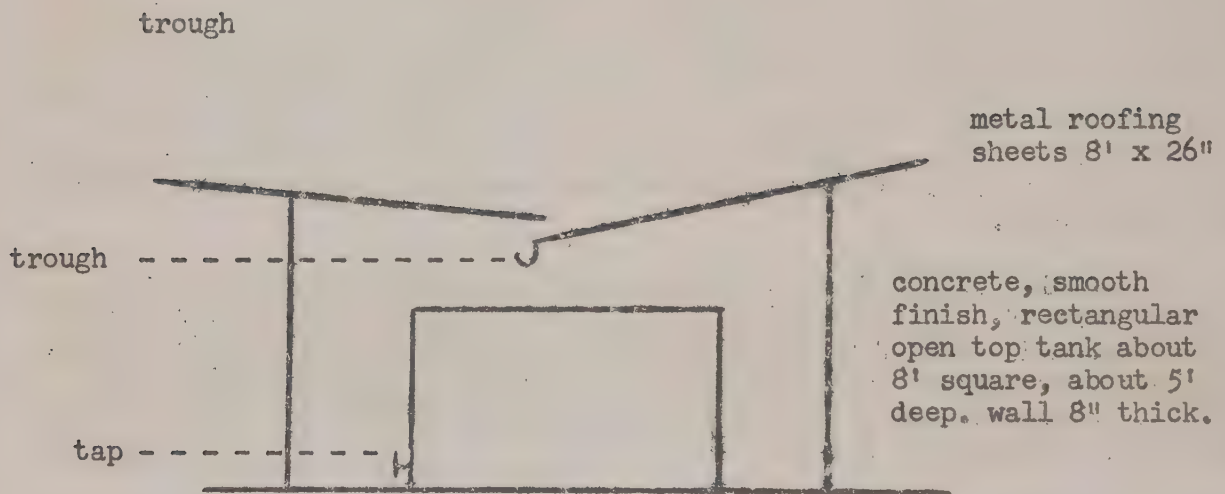


Diagram I.

PREFERRED TANK AND CATCH AREA

The tanks are not now used to capacity, rarely lasting more than a month. Their proper use would require some over-all supervision concerning catch areas, periodic cleaning and rotation of use. Several tanks are so managed now and indicate the value by yielding a water supply after other tanks are dry. Upon several inspections about half the tanks were found in good condition of cleanliness and repair. Cleaning is made necessary by the daily fall of leaves from the breadfruit trees and by the inflow carrying partly decayed leaves into the tank from the catchment areas. Roofing of the tanks and frequent removal of leaves from the catchment areas is helpful, but is not a constant practice. One factor in the incomplete use of tanks is the scarcity of the roofing strips used for the catchment areas.

A contributing factor to the neglect of the tanks is the luxury nature of this water supply. The wells never fail. In dry spells the women carry water from the wells for washing and coconuts are used for drinking in extreme drought. When the nuts are scarce even the well water may be drunk. The water from the taro pit wells is quite sweet. In extreme dry spells the tanks are dry long before the plant life suffers from lack of rain. The tanks are an aid to the economy of time and effort and probably contribute to the health of the populace but they are not an essential. They are highly prized for prestige, alone. Tanks most recently built are larger than the early tanks and appear to be more easily managed.

The water tanks serve as breeding places for mosquitoes. This is controlled by de-roofing the tanks and letting sunlight in. The larger tanks are not easily uncovered and probably copper screening might be a better solution to the mosquito problem.

Tanks on the outer islands have fallen into disuse because of the amount of care required to keep the water from them useable. Water stored in the concrete tanks was still of good quality after two months. Their position above ground and the high sides make them unlikely to contamination by children.

The contamination of the wells is chiefly from surface drainage, most abundant at the central well on Touhou where bathing and clothes washing is a daily practice quite close to the well. This central well supplies the wash water for the entire village whenever cisterns are at a low level. There is traffic throughout the day about the well. The children play with small buckets in imitation of the water carriers. Loose sand and gravel gradually reduce the water depth, and require periodic removal, at which times the rock wall is repaired and brought to ground level. This use of the well is probably no hazard to health, but habits of use are transferred to other wells used for drinking water. The use of concrete is known in the construction of the tanks. Its use to make raised rims would eliminate much of the present gross contamination.

The periodicity of the rainfall which controls the state of the food-supplying trees is now the only very serious problem in water supply.

Shelter

The traditional shelter and clothing of the Kapingas are admirably adapted to the climate. In contrast, the adoption of foreign clothes habits and foreign building material has proved unhealthful. Shoes, worn part of the time because constant wear is impossible, introduce the hazard of softened natural foot covering which is incapable of withstanding the wear and tear of coral. Constricting temperate climate clothing is uncomfortable and prevents proper body cooling. The laundry methods in use are not suitable for the care of such clothing, adding much time to that required for repair.

The few board houses roofed with metal strips are hot, dark, dirty and harbor cockroaches, ants, mosquitoes and flies. The open sided pandanus thatch roofed, coral gravel floored house is so far superior that only the strongest urge for prestige and the possession of abundant funds have accomplished a change from the traditional house. There is an indication that as soon as the termites have destroyed the few present board buildings no more will be built. Reversal to a normal type of clothing for the climate is less likely because of the well established church requirement that clothes be worn by all who have them.

Health

Trauma and communicable disease are the two principle causes of casualties. Long adaptation to the environment is evident in resistance to the effects of sun and sea and coral gravel. The keratinized layer of the sole of the foot is usually 5 mm thick, which permits running and walking on the coarse sharp gravel of the islands and reef. Feet and legs, however, are a frequent site of injury in the form of abrasions and lacerations. Puncture wounds are common and there are occasional fractures. Many of the abrasions become subcutaneous abscesses which are well circumscribed. The same type injury in the non-immune new-comer leads to a diffuse inflammation with lymphangitis and lymphnode enlargement.

The inhabitants are subject to sunburn, and they, as any pale-skinned new-comer, must become readapted if unexposed to the sun for long periods. A chronic conjunctivitis localized to the exposed areas of the conjunctiva is prevalent. It occurs most often in fishermen who do not wear hats or who cannot because of the type of fishing such as netting on the reef during which the fishermen are submerged frequently. Others who spend hours in the sun, develop the same type lesion to a milder degree. In the fishermen the cornea adjacent to the pinguecula acquires a pannus which with repeated injury becomes opaque. In its mildest form this lesion is a congestion of the conjunctiva limited to the exposed areas, and most intense at the pinguecula. Repeated long exposure to sun aggravates this. Some of the fishermen have attributed the affection to the use of swimming goggles. However it occurs in the women who may paddle in the bright sun for a few hours, but who do not use swimming goggles. The symptoms are like those of "snow blindness" with a feeling of "sand in the eyes".

Drowning is infrequent considering the amount of time spent in the water from infancy to old age. There have been three deaths from drowning in the past 3 years: One child fell from a tree into a taro swamp, smothering in the mud. Another waded out too far on the reef. A fisherman drowned in the swift current of the pass.

The injuries due to sea fauna are fish bites, puncture wounds and lacerations from fish spines, lacerations from crab and lobster spines and claws, and punctures from sea-urchin spines. All these are not different from similar lacerations and punctures received from metal instruments. If the wound remains uncleansed it responds with the same type of suppuration as that seen in abrasions from coral or other injuries. The wounds heal rapidly and without suppuration if thoroughly cleansed by some such method as soaking in a mild antiseptic solution, if superficial or by opening and cleansing if deep.

It is stated that several types of poisonous spines are encountered such as the cone snails, a dark-colored sea-urchin, and a fish camouflaged to resemble the rock bottom. "Jelly fish" are numerous and their tentacles produce a transient itching and vesiculation. A yellow coral with fine branches produces the same type of lesion.

The daily use of open fires leads to burns, usually of infants.

Falling coconuts and fronds are a potential source of injury thoroughly understood by the inhabitants who keep the ageing fronds cut from the palms on Touhou and Werua where also the nuts are harvested young for drinking before they reach the falling stage.

Stone bruises are common. They are large and longlasting. The keratin layer protects, but prevents the drainage of the hematoma of a stone bruise which may disable for months. When the stonebruise is finally exposed by wearing off the keratin covering, a rough crevassed region is left which might be mistaken for serious diseases by the uninitiated.

Fish hooks and knives are widely used and produce their usual casualties.

Communicable Disease

The lack of any accurate concept of the spread of disease, and the personal habits of this compact population, bring about a rapid spread of such diseases as acute upper respiratory tract infections, acute epidemic conjunctivitis, skin infections, and yaws. A display of this type spread followed the cowpox vaccinations of June, 1950. For the following month accidental vaccinations occurred in several families in which some of the members had escaped vaccination at the physicians visit. Many of the vaccinated showed wide distribution of large vaccinia lesions.

For a month or two following the visit of a boat there are epidemic sore throats, colds and intestinal infections characterized by diarrhoea. These epidemics are like those occurring in any isolated community when the isolation is broken by visitors introducing a new respiratory tract and

intestinal flora. The boat that brings back the student group for summer holiday from Ponape is the bearer of the greatest single burden of infection. Intestinal parasites, respiratory infections, pink eye and, reportedly, gonorrhoea are the principal offenders.

Hands, mouths, clothing, sleeping mats within the family soon come to bear the same flora and fauna. Dishes are gradually coming into greater use to replace the disposable type such as breadfruit leaf plates, coconut leaf plates, coconut leaf platters or coconut shell bowls. The dishes provide an excellent medium for exchanging acute infection because of the cold water washing technique, but even hot water methods might be presumed superfluous so long as the common eating method with fingers dipped into the same bowl persists. The spread of disease in this group is much like that in an individual; the entire surviving population becomes immune shortly after the introduction of a new agent of infectious disease.

Isolation of infected individuals is an impossibility at present. The exposure of a newborn infant to the group bacteria is an example of how little comprehension of bacterial disease exists. All newborn infants are subjected to mouth to mouth transfer of infectious agents of many female relatives, friends and assistants at the birth. An infant cry is a signal for repetition of the transfer. The death records indicate little mortality from this practice, but the morbidity is high. Thrush fungus is prevalent, as are coughs and colds in the newborn group. It would be difficult to ascribe a more likely source for the infection of a four months old infant who died of *tuberculous meningitis, than this mouth to mouth transfer.

About one fifth of the populace has fungus infection of the skin. Four types are identified clinically, from which fungi were demonstrated in potassium hydroxide preparations. These are Tinea imbricata, Tinea versicolor, and Tinea cruris. Tinea favosa is uncommon. Conditions are ideal for the continuance of fungus infections and for their transfer. There is an indication of decreasing incidence in recent years since soap and rainwater have been more regularly available.

Tuberculosis is not common. Occasional cases of cough with emaciation have occurred, and such patients have been isolated in a house set aside for this purpose. "Isolation" as practical here means little more than a change of scene for the usual bacterial transfers. Patients isolated at the infirmary for acute infections were visited regularly by family and friends. Spouse slept with spouse and friend with friend on the narrow infirmary cot. The usual eating habits are practiced under isolation as at home. At funeral ceremonies the deceased is kissed good-bye by all regardless of the cause of death. Under the circumstances, if tuberculosis were common it should be more evident. Only one case of probable tuberculosis was seen in five months, that of a four months old infant dying of tuberculous meningitis. Of the many coughs treated at the infirmary none was found with physical signs of tuberculosis. No emaciated sick people with cough were seen.

Arthritis is uncommon. Two patients were seen with symptoms and signs characteristic of mild infectious arthritis. The women complain of pain in the sacroiliac region radiating down the leg. These patients gave a history of some type of unusual activity prior to the attack. Such work

*.Clinical diagnosis

as pounding pandanus leaves or mashing breadfruit or pandanus pulp with a heavy pounder is done periodically with little preparation for the strenuous exercise of muscles required. The young women pride themselves on ability to carry heavy loads, and occasionally complain of the same symptoms.

Psychologically the people appear well adjusted to their situation of isolation. Many of the older people recognize the advantages of climate, location and food supply. These have returned after visits abroad to spend their remaining days here without regret. Youth wants to get away. Many of them return with appreciation that the contrast with other places is in favor of Kapingamarangi. Ninety Kapingamarangi people have migrated to Ponape (village of Porokiet). The reason given by some, and this is agreed to by the leaders at Kapinga, is that the atoll will support only a limited number, and that 500 is too large a population.

No severe psychoses were seen. Certain young women are noted for hysterical attacks attributed to seeing ghosts. There is some concern for personal health usually manifested by calling for medical aid for slight aches and pains. This apprehension appears to be based upon the concept that pain is the only symptom of disease. This is further emphasized by the patient's failure to call for help until other symptoms and signs are well advanced when pain develops. This is not out of proportion to the degree of education concerning disease processes. One case of presenile dementia was seen.

No cancer was seen, either in skin where it would be obvious, or as signs of internal disease. Epidermal inclusion cysts (wens) are common and two lipomas were seen. No basal cell epitheliomas were seen.

Sterility of women is a common complaint. There are 101 married couples, 29 of which have no children. The cause of this was not learned. The reputed frequency of gonorrhoea might explain this and the frequent occurrence of unions with but one child. However, the only signs or symptoms called to my attention despite my frequent requests to treat any cases of gonorrhoea was one case of recurrent bartholinitis and one case of acute epididymitis.

Parasitism

Specific evidence of disease due to parasites is lacking. Faeces from 275 people were examined for intestinal parasites and 100 found to carry at least one parasite, an incidence of 36.4%. Hookworm 21.9%, and pinworm found in 4 of 20 NIH preparations represent the common intestinal parasites. Protozoa were rare. Blood parasites were not found in 20 thick and 20 thin preparations stained with Giemsa stain. Even though no direct evidence of disease from these parasites was found, such a burden of parasites is a hazard. Twenty-four carried both hookworm and whipworm, both parasites producing blood loss. If this population were investigated for anemia, abnormality might be demonstrated due to these parasites. Lice are common.

Anomalies

Anomalies are infrequent. One boy with a mild degree of pigeon breast is apparently not handicapped and has no other obvious anomaly. One small pit in the pinna of an ear was classed as a remnant of a branchial cleft because it had been present from birth. Two children with apparent endocrine dyscrasia were seen. An 8 year old boy with Simon's disease, and an 18 year old girl without secondary female sex characteristics. The usual age for development of secondary sex characteristics of the female is 12.

Of a debatably anomalous nature was one case of hydrocephalus, a boy aged 4 with fontanells open and head circumference increased. In the same category are two cases of mild spastic paraplegia.

Mutilation

A mild form of mutilation of ear lobes was discontinued when church replaced priesthood. Women still pierce the ear for ear rings. Youths scarify their arms in commemoration of early sex experiences, usually with a glowing cigarette.

Medical Care

In 1947 an infirmary was built on Touhou. This is a native type house of post and thatch construction, separated into two rooms by a partition. The infirmary is equipped with utensils, simple instruments, two beds with mattresses, three small tables, instrument stand, shelves, examining table, benches and a chair.

The medical aid, Samuel (June to August) relieved by Masao (August to November) works under the remote supervision of the staff of the Ponape hospital from which supplies are replenished periodically. Beginning in August 1950 the periods were increased from two months to three months. The medical aid makes inspections and, through the assistant chiefs secures the burial of refuse heaps, burning of trash and the cleaning of water tanks, isolation of pigs and spraying to reduce the flies. The persistence and success of the fly spraying program is largely due to the enthusiasm of the assistant chiefs. The flies are convincingly fewer on Touhou and Werua where the spraying is done than on the outer islands. There is no comparable program to reduce the ant or cockroach population.

The medical aid acts as the people's physician, prescribing, while they last, the simple and harmless remedies which, under the circumstances can be the only ones supplied in quantity. These remedies are given on the basis of a symptom: A cough received medication A, a headache receives medication B and a stomachache receives medication C. A patient with all three symptoms gets the three remedies. Abrasions and lacerations are cleaned and bandaged in a manner commensurate with several months training on the basis of complete ignorance of the concepts of infection and asepsis.

The aid enjoys some prerogatives of the former medicine man without the latter's social position of respect due to age and training. This situation leads to certain mild conflicts, as between the assistant chiefs and the medical aid. The assistant chiefs are highly respected executive officers of the chief. One is the son of the former chief. The medical aid is not now looked upon as having attained a mature position of responsibility.

It is a favorable commentary on the sound policy of the basic program that even with these handicaps, the people are benefitting from the infirmary and its personnel. There is almost daily use of the facilities for wound dressing. The gauze and bandage material provided is still preferred for head dress and arm band decoration and may be replaced by a home bandage. Many prospective patients treat their own wounds at home with unsterile bandage or HAU leaf covering until, in some instances, abscesses develop. Others come for treatment of very slight abrasions, indicating a possible appreciation that early treatment may prevent later trouble. All cases of severe injury are brought to the infirmary.

The infirmary is serving a need. It is a symbol to the people that there is an outside interest in their welfare and it serves as a meeting place from which sanitation and health knowledge can be spread as soon as the planned personnel is available. A government poster, a translation for which was prepared by Masao the temporary aid, has been displayed prominently in infirmary, church and school. It deals with flies, mosquitoes, rubbish and disease and has received much attention and comment. The enthusiasm for the health program is spreading but still remains largely with the leaders. Serious illness is still treated by long established primitive methods.

Medical Lore and Practices

The gods of the Kapingas are deified ancestors of their atoll home who inhabit the sea outside the reef. These gods are the benefactors of the people and are all powerful.

The ancient priesthood acted as intermediaries with these tribal gods, requesting their aid to ward off afflictions or assist in special projects.

The spirits of the recently dead reside in the lagoon and return to wander about their former home on land. Some of these ghosts are mischievous or have grudges against specific living enemies.

Medical practice for the treatment of disease was traditionally in the hands of practitioners or magicians, who had power passed on from their ancestors. The power consisted of methods of control of the ghosts of the lagoon and of formulae for specific remedies. Any obscure illness is attributed to seeing these ghosts, the sight of certain spirits producing particular illnesses.

One of the commoner ghost-caused diseases is a condition of young women called HOTUPE (fits). It is a temporary apparent disorientation of the attacked patient who may run into the sea if not restrained. The attack starts suddenly with a series of loud, shrill screams resembling those of a suddenly hurt child. The cries follow a stereotyped pattern immediately recognized as being those of the individual attacked. Some have advocated as treatment a lack of restraint; the patient runs into the sea (on the smooth part of the reef) and recovers immediately.

A disease characterized by menorrhagia is attributed to seeing two ghosts.

A practitioner maintained his position by the success or failure of his exorcising and his herbal remedies. Herbal remedies were, and still are, used for common afflictions. Some former remedies have been discarded in favor of some imported from Nukuoro (probably once the home of the Kapingas). These remedies are carefully written and indexed in a note book prepared by Alfred Patterson who was trained in the ancient practices. He recorded them while visiting Nukuoro. Their antiquity is not known. Some differ little in principle from remedies devised by any one desiring a purge, relief from pain or irritation or for hemostasis. The complexity of some formulae hints of their possible origin in secretly compounded magic. It is stated that the remedies must be made and used in a certain way to be effective. This is the reason given for keeping the formulae carefully guarded.

One series of remedies, totalling 12 were in a separate category called sacred. These are all mixtures of the juices of plants, for external and for internal use. They are described completely in the appended list. One internal and one external remedy are described here as examples.

A. A remedy for headache.

- a. Three yellow leaves of PUKA (Pisonia grandis)
Three green leaves of PUKA
Three leaflets of TUA KIMOA (Vigna marina)
- b. A husk of coconut that has been soaking in the sea to rot, is soaked in fresh water for a day.
- c. A hole about a foot deep is dug in the ground and this lined with a leaf of NGAUNGAU (Alocasia macrorrhiza) ("ape" in Hawaiian).

After pounding the leaves in a bowl, a coconut cloth is used as a strainer and the juice squeezed into this hole.

- d. The water is wrung from the coconut husk and added to the juice in the "ape" leaf.

The patient lies on his back immersing his head in the mixture allowing just nose and mouth above the fluid. The treatment is given for an hour or less for three successive days if necessary. If the patient has not recovered after three days of rest from treatment another series of three is given.

B. A remedy for bloody diarrhoea and fever.

A stem of fruit of WARANGA (Pipturus argenteus).
6 fruits of the HUATORO (Triumfetta procumbens), and a 3-inch square of outer layer of coconut trunk.

These are pounded in a bowl and the juice squeezed through a cloth into a small immature coconut about half full of its juice. The mixture is heated and drunk for the first dose and repeated cold for two more doses.

A second category of remedies is used because of well demonstrated ability of the remedy to produce a certain effect. One of these, WARE WARE is used as a home remedy for any one not feeling well enough to be up and about his work. A mature coconut is opened with strokes of the sharp edge of a knife blade leaving about 1/3 of the shell as a cover. The juice is saved, the meat shredded with a scraper including all of the thin brown coating of the meat. The shredded meat and juice are replaced and the covered nut cooked in the ground oven. The mixture is drunk hot and produces a moderate purging.

An absorbent dressing is made from the hairy portion of the "Bird nest" fern (Asplenium nidus).

Round flat leaves, such as the HAU (wild hibiscus) (Hibiscus tiliaceus) are applied either directly or by use of a gum, to abrasions and lacerations to keep the flies away.

Coconut water from the young nut is given new-born infants pending a supply of milk from the mother. This water produces a purging, thought desirable by the Kapingas, sometimes sufficient to produce a bloody mucous fecal mass. Microscopic examination of such material shows many macrophages filled with the coconut oil droplets.

Obstetrical care

Obstetrics is entirely the field of older women, some of whom have earned a place comparable to that of midwife by attending many births. From the onset of pregnancy the prospective mother is set apart and advised by the older women. During the first month of pregnancy she does not work but carries on her usual tasks thereafter because it is thought she will be unable to carry on labor properly otherwise. Sexual intercourse is tabu throughout pregnancy and thereafter for one year. There is a strong belief in prenatal influence, and many tabus concerning what the mother should look at and avoid seeing. A first pregnancy and delivery are accompanied by much ceremony omitted from subsequent ones. Traditionally at the onset of labor the obstetrical party retreated to a remote island. Now many deliveries take place in a neighbor's or friend's house within the village.

There are apparently two schools of thought concerning the desirability of early bearing down. Some urge the mother to exert herself throughout labor, others insist it does no good until the third stage of labor which is recognized by the bursting of the amniotic sac and the resultant flow of watery fluid. Long cloths are tied about the epigastrium and pulled tight to assist the expulsion, frequently in the early stages of labor. The mother is provided with a rope tied to the upper part of a house post against which her feet rest while she pulls. Primipara were found exhausted in the early hours of labor with the infant head still above the pelvic brim. There is apparently agreement of all the older women that once the amniotic sac has ruptured the delivery must be speeded because the child will inhale blood. One severe perineal tear was seen which may well have been due to a hurried third stage. There is comparable urgency to speed the placenta and membranes, even to exerting traction on the membranes, if there is delay, to the point of tearing them free. Traction on the cord is avoided. The delivery bed is an old mat of pandanus. The mother is draped to keep the flies away.

The infant is received in the hands of the midwife who immediately cleanses the mouth and nose of the infant by sucking them free of mucous. The tongue of the midwife is inserted into the infant's mouth to search out any foreign material. This process is repeated especially if the infant cries. It is thought such cleansing must be done to permit the first breath and that it must be repeated to insure that it is a complete cleansing process.

Formerly the cord was cut about three inches from the umbilicus with a sharp sea shell and left untied. Only rare hemorrhage occurred. Now cords are tied with thread. The infant is immediately washed with fresh coconut cream.

Any indication of a concept of asepsis is lacking. The use of clean cloths is a gesture in that direction and the cleanliness of the cloth is of the cold water variety. A bath in the ocean is attempted by some immediately prior to delivery. The mouth to mouth aspiration is repeated by relatives and friends of the family. The first solid food of the infant, given pending the mother's milk supply, is prechewed.

The placenta is washed, wrapped in a cloth and buried in the channel between the islands. The cord stump is allowed to drop off and is then placed, if from a female, in the base of the leaves of a lily plant, and if from a male, in the fold of the leaves of a young coconut tree.

The mother is urged to take food throughout labor and immediately after delivery, even though exhaustion may cause its immediate vomiting. One sixteen year old primipara was delivered while chewing a pandanus key. Maternal rest following delivery is looked upon as a sign of weakness, and an effort is made to avoid the stigma. The mother sits up shortly after delivery. She travels to the ocean for a bath as soon as she can walk, and is usually visiting neighbors within three days. A journey from an outlying island is undertaken the day after delivery. Some of the women are in a state of exhaustion, but apparently no concessions are made for a prolonged or difficult labor. A tea made from any one of several varieties of plant is routinely taken by the mother shortly after delivery.

The medical aid and the medicine man professed ignorance of all obstetrical practices.

There is room for the application of a few simple remedies in delivery and the puerperium. Two instances of omphalitis in the newborn were seen. Thrush fungus was severe in four mouths of newborns. Suppurative skin infections were seen in four. One infant had bronchopneumonia.

None of the infants died, and infant mortality is said to be low. One is compelled to great caution in advising any change of procedure in the face of such a mortality rate and absence of alternatives. The mouth to mouth practice which violates the principle of isolation of an infant from new bacterial flora goes all the way in the opposite direction and brings to the infant almost all the bacteria it is going to meet. The abandonment of a practice which achieves a difficult task, that of removing mucous from the upper respiratory tract, might be harmful, especially when we consider that the same result is attempted commonly in medical practice by wiping out the mouth with sterile gauze and aspirating with a sterile catheter.

I believe the people are quite anxious to accept innovations in their obstetrical practice, but both equipment and personnel must be available before any improvement is possible. The medical aid might be able to introduce an alcohol cord dressing and a perineal pad soaked in some antiseptic solution such as is commonly available at infirmaries.

Two puerperal deaths have occurred in the past two years during which time there have been 45 births. The cause of the deaths is not known. There were 3 infant deaths in the same period.

There is shown in Table 1 a record of seven weeks infirmary visits as an indication of the conditions diagnosed and treated there. In addition house calls were made during the five months of residence for the following probable conditions.

Auricular fibrillation with failing circulation	M.90.
Bronchopneumonia	F.74.
Ruptured ectopic pregnancy	F.21.
Early pregnancy	F.20.
Miscarriage of macerated foetus, 4 Mo.	F.21.
Recurrent abscess Bartholin's Gland	F.15.
Acute epididymitis	M.18.
Chronic arthritis, hypertrophic.	M.60.
Tuberculous meningitis, death.	F.4 Mo.
Coronary occlusion, death.	F.81.
Bleeding umbilical cord (poor tie)	F.1 d.
Suppurative omphalitis	F.2 wks.
Bronchopneumonia	F.6 d.
Hysteria, (Marital problem)	M.24.
Hysteria,	F.21.
Fever of unknown cause	F.24.
Exhaustion 2d.post partum	F.30.
Dystocia - Delayed Rupture of Membranes	F.31.

TABLE I

TABLE OF CONDITIONS FOR WHICH 161 PATIENTS MADE 563 VISITS
TO THE INFIRMARY
FROM SEPTEMBER 21 TO NOVEMBER 11, 1950.

Lacerations and abrasions	27
Acute epidemic conjunctivitis	20
Tooth extraction for caries	17
Upper respiratory tract infection	14
Tinea	13
Cough	10
Infected lacerations and abrasions	7
Suppurative gingivitis	6
Headache	6
Stomachache	5
Abscess, unexplained	4
Acute otitis media	4
Vague and mild symptoms	4
Tooth ache, caries (no extraction)	4
Back strain	4
Yaws, possible	4
Yaws, probable	2
Thrush stomatitis	4
Abscess jaw, due to dental caries	3
Unexplained fever	3
Seborrhoeic dermatitis	3
Burns, accidental	2
Acute conjunctivitis (sun exposure)	2
Chronic infectious arthritis?	2
Menorrhagia	2
Amenorrhoea	2
Fracture (arm, fall due to epilepsy)	1
Chronic suppurative otitis media	1
Peptic ulcer ??	1
Diarrhoea	M.4.
Suppurative lymphadenitis (head lice)	M.3.

Summarized, these lists indicate no great variation from the conditions prevalent in any small community where the population is subject to a great deal of trauma in daily activities and where the personal sanitation is not on a high level.

One month's visits at the infirmary are recorded as 286 visits by 122 patients. The commonest complaint was cough and sore throat of which condition there were 38. Trauma, principally as lacerations and abrasions, was second with 19 instances, 6 infected. Teeth and gums were the cause of numerous complaints. There were 18 patients with tooth ache from carious teeth and five with very severe gingivitis. The natural history of tooth decay is displayed prominently in all adult mouths. Many gold and silver crowns and fillings are also seen (Japanese period, Ponape). Gingivitis is prevalent after 20 years of age, and appears to offer a fertile field for health

improvement by education concerning well established methods of mouth hygiene. Tooth brushing with coconut husk fiber is practiced by some. The forty teeth extracted for caries with pain represent a very small part of the teeth requiring care.

TABLE 2

THE AGE DISTRIBUTION OF THE RESIDENTS OF KAPINGAMARANGI
NOVEMBER 1, 1950

AGE	M	F	TOTAL
Under 1	3	9	12
1	10	10	20
2	5	5	10
3	5	10	15
4	4	6	10
5-9	28	31	59
10-14	24	26	50
15-19	28	24	52
20-24	16	33	49
25-29	14	16	30
30-34	14	13	27
35-44	25	25	50
45-54	23	18	41
55-64	14	21	35
65-74	8	12	20
75-84	1		1
85-	1		1
	<u>223</u>	<u>259</u>	<u>482</u>

There are no exact data concerning births and deaths prior to 1947. No diagnoses of cause of death are available.

The Bernice P. Bishop Museum has kept a file of births and deaths since 1946.

YEAR	BIRTHS			DEATHS
	M	F	TOTAL	TOTAL
1947			11	7
1948	7	5	12	11
1949	10	10	20	9
1950	3	10	13 (To Nov.1)	5

Epidemiology

The prominent etiologic factors of the diseases prevalent at Kapin-gamarangi are of considerable epidemiological interest. The commonest chronic disease is "ring worm" due to four varieties of Tinea. The control of these skin diseases is now frustrated by the household and personal sanitation of

the patients. Cleanliness of the hot water and soap variety is probably the basic factor necessary for progress in medication for these diseases. The families free from fungus infection are those best equipped for cleanliness. One advantage in a large constant supply of rain water on Touhou would be the proper use of soap permitted by soft water baths, now indulged in during showers and when soap is available. Clothing also requires sterilization by boiling water, at least, and there is abundant fuel to permit proper laundering. Education to the effect that heat would be less destructive than the severe pounding now administered to clothes would yield a return in both economy and health.

Parasitism is also affected by a lack of proper use of soap and water. Head lice, pin worm and whipworm and possibly hockworm as spread here are subject to some control through care of the family clothing and mats. The usual methods of spread of whipworm and hookworm appear not to be the most important factors in this community. The regularly recurring importation of certain parasites, including hookworm, appears to be a prominent feature subject to control by treating the carriers at the source of infection (principally Ponape). Disposal of excreta, though subject to improvement, is questionably a cause of spread of hookworm here where there is a low incidence in those who have not been away from the island, and where there is a family grouping of the carriers. The slight spread of hookworm is likely of the direct type which here spreads whipworm.

Circumstances that reduce the probability of spread of hookworm by the usual method of contamination of muddy soil are here the absence of general soil pollution and the absence of mud secured by spreading coarse coral gravel on all working areas and a coarse sand on the main thoroughfares. Rainfall, though in annual quantity sufficient (80 in.) to permit hookworm spread is so intermittent that the soil, even in the few ungravelled areas is dry for months at a time. The few small areas kept wet by laundering and bathing with well water are a possible region of spread of hook worm in the usual manner. A spot map shows no increased incidence in the immediate vicinity of these areas.

The high incidence of whipworm and low incidence of Ascaris point to some special conditions to account for the deviation from the rule that whipworm and Ascaris are parallel infections. To favor the low incidence is the isolation of pigs from each other and from the habitation. This isolation is not complete enough to account entirely for the low incidence. The sty areas are well drained and dry for months at a time.* The watering utensils are Tridacna shells, dry most of the time. There is no contamination of the sty areas by humans. The latest pig stock was imported prior to 1941. The pigs are kept tethered or singly in small rock pens. Ascaris may be absent from the pigs. None was found in ten pig faeces specimens and adjacent soil. Such Ascaris as is brought in from foreign countries by humans would find little opportunity for survival under the prevailing circumstances. It is quite likely that little Ascaris is imported because the traveling population is above the age commonly acquiring Ascaris.

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* Ascaris requires 30 days in moist soil to become infective.

The high incidence of acute infections due to visiting boats and returning travellers is a serious economic load for this community. The only apparent help lies in combatting with medical care the acute stages to avoid serious complications. The problem is that of any isolated community which must (preferably gradually) acquire immunity to the world's burden of bacterial and viral flora if it is to survive without return to its state of isolation.

The isolation which permitted Kapingamarangi to remain unvisited by whites until 1871 also accounts for the avoidance of the devastating epidemics which so seriously reduced the population of other atolls. There have been seven epidemics, all following the visit of boats. The first, like all the others attacked the entire population, but caused only a few deaths. The chief characteristic of this first epidemic was that it caused listlessness and death in a few days.

The second occurred between 1900 and 1910 and is described as a wasting disease with cough.

The third was synchronous with similar epidemics in Ponape and Nukuoro between 1910 and 1920 and characterized by severe headache.

Neither the fourth or fifth caused any deaths and they had the characteristic manifestations of whooping cough and of mumps. No orchitis occurred with the mumps.

The sixth was a bloody diarrhoea dated as during the Japanese times. Only a few people died.

About 1940 a severe sore throat followed by a fine red skin eruption and peeling of the skin caused the deaths of a few children and no adults. This was probably scarlet fever.

There has been a time when tuberculosis was more prevalent than now, and chronic skin diseases have decreased. The German expedition of 1910 described the populace as nearly all affected by skin disease.

The impression gained is that this very susceptible group of people has weathered many epidemics with much less loss of life than reported in other isolated groups, and that there never has been an epidemic that killed large numbers. The largest number dying in any epidemic is probably ten or twelve. The largest number of names with dates of death that could be elicited was a group of 6 occurring in the 1922-24 period.

The worst death-dealing condition was starvation in the famine of 1915-1919 when 60 people died in Kapingamarangi and 40 Kapingas removed to Ponape in very poor condition died there. It is a reasonable conjecture that the deaths would not have occurred had not the local governor prohibited the use of coconuts for food and restricted fishing, by requiring men to work at copra production.

Immunization against small pox by vaccination showed this group in June 1950 to be entirely non-immune, substantiating the absence of any history of an epidemic of that disease. No epidemics are reported characteristic of

diphtheria, chicken pox or measles. A large proportion of the population has been immunized against diphtheria (June, 1950). The other two diseases must be considered as potential serious hazards, and their importation avoided.

The most fertile field for the application of preventive measures of the early treatment type is that of trauma. Probably no more than a third of the cases of mild trauma are seen at the infirmary in an early stage.

Judging from the number of home made bandages adorning arms, legs, fingers and toes, home treatment still predominates. This is emphasized by the number of cuts and scratches seen in a state of suppuration. Some of the bandages cover the scarification practiced by youth to commemorate their early sex experiences. These wounds are usually sterile, the favorite mark being a cigarette burn on the arm.

Thorough cleansing and covering of wounds is made more urgent by flies which are immediately attracted by any open wound.

High infant morbidity of acute infections of skin and respiratory tract is associated with long established practices some of which must persist until proper substitutes are available such as good obstetrical practice. Much, however, can be achieved by hot water and soap cleaning of clothes used for the infant and its bed. As simple as such devices appear their use requires the changing of long held concepts and despite an evidenced willingness to learn, reasons for change are difficult to grasp. Some idea of the difficulties are suggested by the finding that a medical aid, after two years of education in basic sciences required instruction in washing hands, cleaning instruments and the handling of sterile material.

Three maternal deaths in the past three years can be understood after observing the obstetrical practices in which, apparently, acquired immunity to tribal bacterial flora replaces asepsis.

Three common insect vectors, flies, mosquitoes and lice are here in sufficient numbers to cause epidemics should the proper disease factor be introduced. Flies now spread wound infection, and the control of this lies in the care of wounds rather than any hope that flies will be eliminated. The mosquitoes are controllable on the principal residential island and are now kept reduced by exposing water tanks to sunlight and by the elimination of all natural casual water containers such as coconut shells. (No anophelenes).

Lice are subject to greater control than now evidenced. In some families the children's heads are kept clipped, mats are sunned frequently, and kept clean. Adults wash frequently with soap. These families have no obvious lice. The small boys are the most conspicuous bearers of head lice. By well established custom the habits of youth are uncontrolled in this society. Gradual education to the liberal use of soap and hot water and hair clippers is possible in this intelligent group. It might be carried on through the medical establishment cooperating with the school.

Rat control is apparently quite satisfactorily maintained by the cats which are no great burden on the food supply because they scavenge all refuse.

Summary

Five months observation, from mid-June to mid-November, 1950, of the health conditions of Kapingamarangi reveals a high degree of adaptation of the people to a salubrious environment. There is a high incidence of trauma and of infectious disease of mild varieties. There is demonstrated the usual reactions of an isolated group to commerce with foreign groups. These reactions emphasize the inadequacy of certain long established practices to meet the new environmental change.

There is indicated some progress toward readaptation to the imposed changes. Under intelligent leadership, education about modern concepts of disease and disease control is establishing the base for improvements of personal hygiene, first aid, and general sanitation.

A better rain water supply would improve the opportunity for better personal and family hygiene. Elimination of the dry reef as a toilet, and restriction of area used would appear to offer less opportunity for spread of disease.

The daily clean up could be extended to the beach areas with a reduction of fly breeding areas.

The present direct ocean disposal system is adequate only with a continued small population.

Appendix A

Medical remedies

1. For pain in the head and hot breath.

- a. Leaf buds of the WORO-WORO, Premna obtusifolia are pounded until soft. The pulp is inclosed in a small piece of cloth and a drop or two of the juice squeezed into the nostrils while inhaling. This treatment is used three times a day for two days if necessary, and, after a three day interval may be repeated for two more days only.

2. For headache.

- a. Three yellow leaves of PUKA, Pisonia grandis
Three green leaves of PUKA
Three leaflets of TUA KIMOA, Vigna marina
- b. A husk of coconut that has been soaking in the sea to rot is soaked in fresh water for a day.
- c. A hole about a foot deep is dug in the ground and lined with a leaf of NGAU NGAU, Alocasia macrorrhiza.
- d. The water is squeezed from the coconut husk into the leaf lined hole and the juice of the pounded plant leaves added.
- e. The patient lies on his back, immersing his head in the mixture for an hour at a time for three days. The treatment may be repeated after three days interval.

3. A post partem medication.

- a. Six small plants of NAU, Scaevola frutescens are pounded and the juice squeezed into a very young coconut.
- b. All of this is drunk, and a similar mixture each day for three days.

4. For a fall from a tree.

- a. Dark grass plants, roots and all.
- b. Leaves of T'HIA, Clerodendrum inerme.
Enough of a. and b. to make a handful is crushed in a wooden bowl 16" long with
- c. three pieces each about 6" long of the growing leaf tip of HALA HALEO (N)*

* (N) indicates a Nukuoran name

- d. The grated meat of a mature coconut (brown husk) is added to a, b, and c.
 - e. Three batches of the above are made and the juice placed in a tarpaulin-lined trench big enough to hold the victim and several buckets of water.
 - f. The patient remains immersed with only nose and mouth exposed until he has a shaking chill.
5. For prolonged menstruation.
- Three sections of the base of TARA TARA, Crinum asiaticum, are pounded and the juice squeezed into water.
The patient sits in the water once a day for three days.
The treatment is omitted for three days and repeated if necessary.
6. Omitted because of its similarity to No. 3.
7. A remedy for bloody diarrhoea and fever.
- a. A stem of fruit of WARANGA, Pipturus argenteus.
 - b. Six fruits of the HUATORO, (N) RAMUTAKE, Triumfetta procumbens.
 - c. A three inch square of the outer layer of coconut trunk. These are pounded in a bowl and the juice squeezed through a cloth into a small immature coconut about half full of its juice. The mixture is heated and drunk for the first dose and repeated cold for two more doses.
8. For hot breath.
- a. Six small pandanus plants.
 - b. Three sprouting leaves of the RAKAUTOROTORO, Polypodium scolopendria.
A coconut shell that has been rotting in the lagoon for a long time is used as a container for sea water. The plants and leaves are crushed and placed in a piece of coconut cloth. This is dipped as a sponge into the sea water and the patient given a sponge bath daily for three days. This is omitted for three days and repeated if necessary.
9. Omitted
10. For pain in the stomach (abdomen).
- a. Three yellow and three green leaves of T'TOKOTOKONGO, Messerschmidia argentea, (beach heliotrope).
The leaves are pounded and the juice strained into coconut water. This is taken daily for from three to six days.

11. For cough.

A piece of bark of T'TOKOTOKONGO, Messerschmidia argentea, and three yellow and three green leaves and three fruit bracts and three leaf buds of the same plant are pounded, the juice squeezed into coconut water and the mixture taken for cough.

12. For chest pain.

TAKAHARU, Allophylus timorensis is used in a manner similar to 11.

13. For a dressing over wet lesions the feathery mass from the center of the "bird nest fern" RAU KATAHA, Asplenium nidus is used.

14. A poultice for boils.

a. Dark grass

b. Three leaves of TUA KIMOA, Vigna marina.

c. The meat of a mature coconut in the green husk stage, grated. The pounded leaves and the grated nut meat are mixed and used as a poultice.

15. To bring boils to a head.

a. Three roots of pandanus.

b. Three roots of KANIU, Ochrosia oppositifolia.
Crush and put in coconut cloth, dip into coconut cream and salt water mixture and rub about the boil towards its center. Repeat for three days.

16. For an itching, scaling eruption.

a. Leaves of RAUTARIA, Terminalia samoensis.

Pound the leaves and sop around the area to stop the itching.

Remedies for puncture by the spine of the NOHU, (rock fish) which is said to cause severe swelling and pain.

1. Catch a NOHU and put the gall bladder juice on the injured spot. This must be done immediately.

2. a. Warm coconut cream in TUKIMA shell.

b. Young fruit of NONU, Morinda citrifolia, with flowers still on the fruit.

c. Two to four rootlets of coconut.

The fruit and rootlets are pounded and the juice strained into the coconut cream.

Place foot in mixture daily until healed.

A remedy for gonorrrhea.

A plant of RAMU TAKE, Triumfetta is stripped of its bark, the stem and leaves pounded and the juice squeezed into water. Each morning a half coconut shell of sea water is drunk. The penis is soaked for one half hour in the plant juice mixture, daily for three days.

REMEDIES in GENERAL USE

1. NONU, Morinda citrifolia flower buds are eaten by women wishing to wean a nursing infant. The milk becomes bitter and the child refuses to nurse.
2. A leaf of HAU, Hibiscus tiliaceus is a favorite cover for any open superficial wound.
3. NGIE, Pemphis acidula bark pounded and squeezed into water. The bitter liquid is taken daily for three days.
4. RAKAU HUNU KIRI, Cassia alata leaves are rubbed on chronic skin infections such as Tinea imbricata.
5. A thread is used to tie the base of warts and similar growths to cause them to drop off.
6. The vapors from steaming concoctions of various leaves are used against various affections of the head.

A cathartic.

The flesh of a sea-urchin with black and white spines is aged for a day, then mixed with some raw and some cooked coconut cream. The mixture is drunk and the limbs and body massaged toward the stomach.

A widely used cathartic, called WARE WARE. A young coconut in the late drinking stage is husked and the top third of the shell removed with the sharp edge of the knife so as to leave a tight cover. The meat and a considerable amount of the brown inner lining of the shell is scraped, and mixed with the juice, the covered shell placed in the ground oven. The whole amount is drunk hot.

A charm against spirits.

Two green coconut leaflets are placed shiny sides together. They are snapped by separating the hands rapidly and then knotted, at first with an overhand knot including both leaflets at junction of distal and middle thirds, and then an overhand knot tied with one leaflet adjacent and just distal to the first knot. This is pinned on the wall near the sick person.

PART II

A PARASITOLOGIC SURVEY OF KAPINGAMARANGI, 1950

Previous reports of parasitism in the East Carolines indicate intestinal parasites as almost universal, and few other parasites found in significant numbers. The isolated position and certain customs of Kapingamarangi relative to sanitation appeared to offer an opportunity for an exception to the rule.

Fecal contamination of the residential islands has been contrary to custom for many generations. The most heavily populated areas are free from mud even in heavy rains because coarse coral gravel is spread as a cover of used areas to prevent muddy surfaces. Thus two of the contributing causes of spread of hookworm and of Ascaris are curtailed.

During July and August of 1950, 283 faeces specimens were brought to the field laboratory in leaf covered coconut shell containers. Samples were removed to tight plastic vials and the remainder of the original specimen discarded (ocean). From the vial sample, iron hematoxylin stained slides were prepared, direct saline suspensions were examined, and zinc sulphate sedimentation-flotation preparations were made by hand centrifuge. Routinely, flotation specimens were examined and thirty-six sediments were examined to rule out operculate eggs, though none were expected.

Originally plans were made for the faeces parasite survey only, however time became available to make a reconnaissance of other parasites. Twenty N. I. H. preparations were made for pin worm. The unexpected absence of Ascaris required explanation, and ten specimens of pig faeces and adjacent soil were examined by saline flotation.

One patient was seen with chills and fever, and similar attacks were said to have occurred in men who had visited Rabaul. Twenty thick and twenty thin blood films were searched for malarial parasites and filarial larvae.

Inspection of patients coming to the infirmary was made for ecto-parasites. Mosquitoes and larvae were collected for identification. It was reported by the authorities here that only one kind of mosquito was present before the Japanese came, a day biting variety, and that the Japanese brought the night biting variety.

A study was made of conditions which might affect parasitism and the observations included in "A Health Survey of Kapingamarangi."

The population is arranged in the following age groups.

AGE	M	F	TOTAL
under 1	3	10	13
1	10	10	20
2	5	5	10
3	5	10	15

AGE	M	F	TOTAL
4	4	6	10
5-9	28	31	59
10-14	24	26	50
15-19	28	24	52
20-24	16	33	49
25-29	14	16	30
30-34	14	13	27
35-44	25	25	50
45-54	23	18	41
55-64	14	21	35
65-74	8	12	20
75-84	1	0	1
85	1	0	1
Total	223	260	483

Results of Faeces Survey

From 275 subjects, 283 faeces specimens were examined and 100 subjects found to carry one or more parasites, 36.4%. There were two common parasites, hook worm and whip worm.

TABLE 3

OVA OF PARASITES FOUND IN FAECES

PARASITE	IN MALES	IN FEMALES	TOTAL	% OF GROUP PARA- SITIZED
WHIPWORM	35	25	60	21.9
HOOKWORM	41	17	58	21.7
E. COLI	4	3	7	
ENDOLIMAX	3	0	3	1.1
IODAMOEBIA	3	0	3	1.1
TRICHOMONAS	2	0	2	.73
GIARDIA	1	0	1	.34
ASCARIS	0	1	1	.34

TOTAL (multiple infections counted as 1) 36.4%

In view of the conditions which would tend to prevent hookworm spread, the history of the carriers was investigated. Table 4 indicates a higher incidence in those who have travelled to other atolls such as Ponape where hookworm incidence is known to be high.

TABLE 4

TOTAL GROUP	275	
TOTAL WITHOUT HOOKWORM	214	80%
NUMBER WHO HAVE BEEN AWAY	164	
WITH HOOKWORM " " "	48	29%
NUMBER NOT AWAY	111	
NOT AWAY WITH HOOKWORM	11	10%

Although this distribution does not prove that the hookworm was acquired abroad, the fact that 80% of the entire group did not show hookworm would indicate the presence of factors limiting its spread in an entirely barefoot population and despite the importation of new carriers at fairly frequent intervals.

A spot map of Touhou Island indicates a high incidence of more than one infection in the same household.

The low incidence of intestinal protozoa in a population living as intimately as this one is worthy of note. The reason is not obvious. The low incidence in Ponape, the most visited foreign port is a factor. The frequent bathing permitted by access to the sea is probably another, which also contributes to keep the parasitization by all types to such a relatively low figure.

The only ectoparasite found is the body louse which must be present in nearly every household, if not all. All small boys with long hair have numerous louse egg cases (nits) attached to their hair.

Pin worm ova were found in 4 of 20 NIH. preparations from the anal region of young children. This establishes their presence, but no conclusion can be drawn concerning the incidence.

The absence of malarial parasites and filarial larvae was anticipated. No anophelene mosquitoes were seen although every opportunity to identify anophelenes was used. There are at least two species of mosquito, a day and a night biting variety. Specimens collected await identification. Complete malaria reconnaissance was not undertaken.

Treatment

The list appended shows those known to have whipworm at the time of the medical field trip from Ponape, August 1950 when medicines were brought for treatment of hookworm. The results of the hookworm treatment are not known because supplies to repeat the tests were exhausted. There is demonstrated in the same table the well known ineffectiveness of oil of chenopodium against whipworm. The oil was used in March, 1950 as part of a mass treatment for supposed Ascaris infection. Thirty-four of the fifty bearers of whipworm are known to have been treated. A complete list of those treated in March, 1950 is not available. One hundred residents were treated, and medicine left for 100 more which was not used. Therefore, at least 175 of those whose faeces were surveyed had had no recent treatment for ascariasis.

Conclusions

There are two common intestinal parasites in the residents of Kapingamarangi, hookworm and whipworm.

The hookworm is probably imported from other islands, especially by the student group returning from Ponape.

Importation of hookworm could be most easily curtailed by treating the group returning from Ponape, before they leave.

Control of the spread of the common intestinal parasites and of ectoparasites lies in the field of general health education concerning personal and family hygiene.

APPENDIX

NAME	HOOKWORM	WHIPWORM	ISLAND	REFERENCE NUMBER	DATE LAST AWAY	DATE LAST TREATMENT	SODIUM SULPHATE	TETRACHLOR ETHYLENE	MAG. SULF.
HAKATOPE	Yes	Yes	W	261	Ponape 1939	3-50	Yes	Yes	Yes
DEHAWAI	Yes		W	264	Ponape 1936	3-50	Yes	Yes	Yes
TANGAMI		Yes	T	268	No	3-50	"	"	"
TARIPURET	Yes		W	271	Ponape 1935	3-50		one egg	
TAKITAK		Yes	W	272	Ponape 1935	3-50	"	"	"
KEREN		Yes	T	277	Truk 4-30	3-50			
ANTIPATI	Yes		W	284	Ponape 1931	3-50	"	"	"
TIOU	Yes		T	285	No	3-50	"	"	"
ARIPETI	Yes	Yes	T	286	Ponape 1946	3-50			
TANIEL	Yes		T	287	Ponape 9-49	3-50	"	"	"
DAUMIRI		Yes	T	291	Ponape 1937	3-50	"	"	"
ANION		Yes	W	292	No	3-50	"	"	"
WASAI	Yes		W	293	No	3-50	"	"	"
TIMOUET	Yes		W	294	Ponape 1935	3-50	"	"	"
SIMATI	Yes	Yes	T	295	Ponape 1949	3-50	"	"	"
NIMISIO	Yes	Yes	T	296	No	3-50	"	"	"
YESIKE	Yes	Yes	T	300	Now in Ponape				
TIRONGORONGO	Yes		T	301	Ponape 1939	3-50	"	"	"

NAME	HOOKWORM	WHIPWORM	ISLAND	REFERENCE NUMBER	DATE LAST AWAY	DATE LAST TREATMENT	SODIUM SULPHATE	TETRACHLOR ETHYLENE	MAG. SULF.
KIKINE		Yes		307	No	3-50	Yes	Yes	Yes
PUREIKI	Yes		T	312		8-23/50	"	"	"
LUISI	Yes		W	316	Ponape 1947	3-50	"	"	"
MATINIA	Yes		T	319	No	3-50	"	"	"
KOULUA		Yes	T	320	Ponape June-50	3-50	"	"	"
TAITOS		Yes	T	323	Now in Ponape				
PELENES		Yes	T	326	No	3-50	"	"	"
TIMOTI	Yes	Yes	W	328	Ponape 1946	3-50	"	"	"
JARI	Yes		W	333	No	3-50	"	"	"
DIENEMANU		Yes	T	339	No	3-50	"	"	"
DILAUE		Yes	T	358	Truk 4-1931	3-50	"	"	"
LIETA		Yes	T	359	No	3-50	"	"	"
ISE	Yes		T	361	Ponape 12-1949	3-50	"	"	"
LIAA	Yes		T	362	Ponape 1939	3-50	"	"	"
HEKENOHO	Yes		T	365	Nukuor 1949	3-50	"	"	"
TOKORAI	Yes	Yes	W	216	Ponape 1949	3-50	"	"	"
SEMETI	Yes		T	221	Ponape 1949	3-50	"	"	"
LUI	Yes	Yes	T	222	Ponape 1949	3-50	"	"	"
RAIMON	Yes	Yes	T	224	Ponape 1945	No	"	"	"
KASTOR	Yes		T	225	Ponape 1939	3-50	"	"	"

NAME	HOOKWORM	WHIPWORM	ISLAND	REFERENCE NUMBER	DATE LAST AWAY	DATE LAST TREATMENT	SODIUM SULPHATE	TETRACHLOR ETHYLENE	MAG. SULF.
KIMURA	Yes	Yes	T	228	Ponape 1946	3-50	Yes	Yes	Yes
LUCAS	Yes	Yes	T	229	Truk 1948	3-50	"	"	"
KATARINA		Yes	T	231	Ponape 1948	3-50	"	"	"
MASUKO	?		T	232					
MISERI	Yes	Yes	T	233	Ponape 1945	3-50	"	"	"
RISE	Yes	Yes	T	235	Ponape June 1949	3-50	"	"	"
TAWHERA	Yes			241	Now in Ponape				
RIMI	Yes		T	257	Ponape 1930	3-50	"	"	"
JOHANIS	Yes		W	367	Ponape 8-1944	3-50	"	"	"
URAK	Yes		W	371	Ponape 1932	3-50	"	"	"
ENIMA		Yes	W	373	No	3-50	"	"	"
MALIKUTI		Yes	T	376	No	3-50	"	"	"
DEDUO	Yes		T	378	Ponape 9-50	3-50	"	"	"
NOWA	Yes		T	379	Ponape 1949	3-50	"	"	"
PILIMON		Yes	T	380	Now in Ponape				
TIONI	Yes		T	381	Ponape	3-50	"	"	"
HUSAKO	Yes		T	387	Ponape 1938	3-1950	"	"	"
LETI	Yes	Yes	T	392	No	3-50	"	"	"
SIANA		Yes	T	401	"	3-50	"	"	"
TURUKO	Yes	Yes	T	402	"	3-50	"	"	"

NAME	HOOKWORM	WHIPWORM	ISLAND	REFERENCE NUMBER	-40- DATE LAST AWAY	DATE LAST TREATMENT	SODIUM SULPHATE	TETRACHLOR ETHYLENE	MAG. SULF.
SUSANA	Yes			404	No	3-50	Yes	Yes	Yes
TEIT	Yes		T	408	No	3-1950	"	"	"
TUHURU	Yes		T	409	No	3-1950	"	"	"
TOPIKI	Yes	Yes	T	411	Nukuor 8-1949	3-1950	"	"	"
KASUKO	Yes			415	Ponape 1935	No	"	"	"
ENELIA			T	386	Ascaris in Ponape				
MIKAR	Yes	Yes	T	416	June 1950?	Now in Ponape			
KORONIKA		Yes	T	421	Ponape June 1938	3-50	Yes	Yes	Yes
PIKITI		Yes	W	422	Ponape 2-1946	3-50	"	"	"
KARATI		Yes	T	426	Truk 6-47	3-50	"	"	"
HANAKO	Yes		T	429	Ponape 4-49	3-50	"	"	"
YOSITARO	Yes		T	434	No	No	"	"	"
BOMUKALAN	Yes		T	442	Nukuor 1946	3-50	"	"	"
MOTOHENI	Yes	Yes	T	448	Ponape 1946	3-50	"	"	"
PONTAIK	Yes	Yes	T	449	No	3-50	"	"	"
KOITI	Yes	Yes	T	450	Now in Ponape				
DERUITI		Yes		451	Ponape 1949	3-50	"	"	"
TAMASUITI	Yes			453	Ponape 1946	3-50	"	"	"
KINTARO	Yes			455	Ponape 15-8-50	No	"	"	"
SIRO I	Yes			459					
ELEATI	Yes			462	Ponape 15-8-50	No	"	"	"
TEKEWO	Yes			463	Ponape 8-50	No	"	"	"
SUPERE	Yes	Yes		428					
TOMIKI	Yes			275					

34 with whipworm had been treated with oil of chenopod

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PART III

BLOOD GROUPS OF THE KAPINGAS, NOVEMBER 1950

Residents of Kapingamarangi whose genealogies are recorded in the files of the Bernice P. Bishop Museum were blood grouped during June, July and August, 1950.

Two hundred were grouped with Anti A and Anti B serum. Of this group, 153 were tested with Anti R₀, Anti rhⁱ, Anti rhⁱⁱ and Anti hrⁱ sera. Of these, 54 were tested with Anti M and Anti N sera.

Subjects were selected in the following categories.

- (I) Those thoroughly documented as "Pure Kapinga"
- (II) Those thoroughly documented as having foreign ancestors.
- (III) Certain family groups.

Methods

The Rh typings were done by the test tube, water-bath, centrifuge method. The A-B groupings and the M-N typings were done by the depression slide method. Two percent saline washed cells were used for all tests.

Lack of refrigeration required the greatest caution to prevent contamination of the test serum. The Anti N serum failed one month after it was first opened. The Anti hrⁱ serum failed after six weeks. The Anti A and Anti B sera were still good after 4 months though the Anti B was slightly weaker.

Control tests were made at intervals to conserve serum. When a control test showed a weakening of a serum, tests done subsequent to the previous control were discarded.

Results

Lack of proper storage facilities and insufficient sera for constant controls limit the conclusion concerning M or N and Rh occurrence. There were found MN, M, and N reactors and all tested were Rh positive. The results of the AB grouping appear in the tables.

Pure Kapingas

Group	AB	A	B	O	TOTALS
Male	0	40	0	47	87
Female	0	32	0	50	82
TOTALS	0	72	0	97	169

Mixed Ancestry

Group	AB	A	B	O	TOTALS
Male	0	6	8	4	18
Female	2	4	3	4	13
TOTALS	2	10	11	8	31

There were 10 subjects with known white ancestry

Group	AB	A	B	O	TOTAL
Number	1	4	5	0	10

ATOLL RESEARCH BULLETIN

No. 21

Notes on Ngaruangel and Kayangel Atolls, Palau Islands

by

J. L. Gressitt

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NOTES ON NGARUANGI, AND KAYANGEL ATOLLS, PALAU ISLANDS

by J. L. Gressitt

NGARUANGI

Ngaruangi is an incipient atoll which includes the northernmost land of the Palau Islands. It is situated about eight kilometers northwest of Kayangel Atoll and 39 kilometers north of Batelthuap Island. Ngaruangi has a reef which is broadly oval, longest north and south, and about 5.4 by 2.7 kilometers in size. The reef has an opening at the northern end, with the reef extending farther north on the west side of the entrance. The lagoon is fairly shallow, being mostly less than three fathoms in depth, and having some coral heads. On the east side of the reef the sea bottom slopes gradually at first, from the reef platform, then suddenly. Soundings between Ngaruangi and Kayangel are mostly between 344 and 430 fathoms, beyond two kilometers off of either reef. The ocean directly north of Ngaruangi is mostly from six to 23 fathoms in depth.

Ngaruangi reef has but a single small islet, near the middle of the east side. In the Carolines, the majority of the atoll islets are on the east sides of the reefs, the prevailing winds being from the east. This islet is about 80 meters north and south, and about 35 meters east and west. It is slightly curved on its eastern, seaward side, and strongly curved on the lagoon side. It is broadest north of the center and considerably tapered at the southern end. The islet consists almost entirely of pieces of rough coral rock thrown up by surf. Most of the pieces are rough or sharp and are largely of the Acropora reticulata type, or of similar form. The majority range from 15 to 60 centimeters, or more, in diameter. Sand and sandy gravel are limited to the lagoon side and the southern tip. The latter is of coral gravel and sand, and its lagoon shore, north nearly to the middle of the island, has a narrow sand beach with coral fragments on the upper portion. The coral rocks are piled higher near the borders of the main portion of the islet and thus the central portion is lower, but quite uneven. The altitude is a little less than one meter above high tide level. A few logs have been washed up on the shore on both east and west sides. Just south of the center is a tripod erected of poles. The reef surface seaward of the islet is gently sloping, but irregular and with rough coral rock or coral fragments.

There is no vegetation on the islet. Animal life is represented by numerous marine crane flies, probably Limonia, subgenus Dicranomyia. Terns were abundant on the islet, but no nests were observed.

Near the north end of the reef, close to the opening to the lagoon, a Japanese freighter, bombed during the war, has been washed up on the reef. A short distance to the northwest of it there is either a large coral boulder or a detached portion of the ship on the reef. On the southwestern portion of the reef there are two or three coral boulders washed up.

Ngaruangel presents an interesting step in the development of an atoll, with the reef well developed and complete except for the single opening, and with a single small islet in an early stage of development, with very little sand, no soil and no vegetation. It may be assumed that if vegetation and additional sand were present earlier, they must have been washed away in storms, and that plants may reappear within the space of ten or more years.*

* Kubary (Die Palau-Inseln in der Südsee, Jour. Mus. Godeffroy 1(4): 1-62, 1873) says, translated, on p. 32, "Northwest of Kayangel is a reef which marks the place, according to the traditions, where the land of Ngaruangel was, but which was destroyed by the sea." And on p. 33, "The Kayangel Group; it was once subject to Ngaruangel...." On p. 47 a legend is recounted, "For a long time there was to the northwest of Kayangel a great beautiful land, and its inhabitants ruled Kayangel....land....called Ngaruangel...." As a result of magic performed by a Kayangel man who had lost his son at the hands of the Ngaruangel people: "The heavens became frightfully dark, and a storm of unprecedented violence raged over all of Palau. Ngaruangel sank into the deep sea and four other small lands on the east side of Palau were likewise swallowed by the waves....."

These beliefs and legends may have no factual basis, but on the other hand, they are suggestive and might justify careful examination of the reefs of Ngaruangel for evidence of former larger islets.--Editor's note.

PLANTS OF KAYANGEL

The following plants were collected or observed on Kayangel Atoll on December 16, 1952 by J. L. Gressitt. The specimens taken were identified by F. R. Fosberg and are deposited in the U. S. National Herbarium. Numbers 1-8 are from Ngariungs Islet, 9-43b from Ngajangel Islet. Those asterisked were seen on both Ngajangel and Ngariungs islets, the remainder only on Ngajangel. The unnumbered ones were seen but not collected. Since these observations were made on a very short visit it is probable that the flora includes many more species not recorded here.

* *Asplenium nidus* L., no. 12

Nephrolepis biserrata (Sw.) Schott, no. 37 (The taxonomy of this species is unsatisfactory. Pacific plants may be something else.)

N. hirsutula (Forst.) Presl, no. 13 (Very young plant, identification uncertain.)

Polypodium scolopendria Burm. f., no. 36

Cycas circinalis L., no. 21

* *Pandanus tectorius* Park., no. 18

Digitaria longissima Mez, no. 40

D. pruriens var., no. 43a

D. timorensis (Kunth) Balansa, no. 43b

Eragrostis amabilis (L.) W. & A., no. 42

Ischaemum muticum L., no. 41

Lepturus repens (Forst.) R. Br., no. 34

Saccharum officinarum L.

Areca cathecu L.

* *Cocos nucifera* L.

Alocasia macrorrhiza (L.) Schott

* *Colocasia esculenta* (L.) Schott

* *Cyrtosperma chamissonis* (Schott) Merr.

Epipremnum pinnatum (L.) Engl., nos. 10, 16 (No. 16 is a young plant and its identity is not certain.)

Xanthosoma sagittifolium Schott

Rhoeo discolor (L'Herit.) Hance

Cordyline terminalis (L.) Kunth

Tacca leontopetaloides (L.) O. Ktze.

Musa paradisiaca L.

M. sapientum L.

Piper betle L.

Artocarpus altilis (Park.) Fosb.

Ficus senftiana Warb., no. 14

Elatostema calcareum Merr., no. 25 (Palau material is with some doubt referred here.)

Fleurya ruderalis (Forst.) Gaud. ex Wedd., no. 22 (Specimen fragmentary, determination doubtful.)

Pipturus argenteus (Forst.) Wedd., no. 15

- Achyranthes aspera* L., no. 33
- Pisonia grandis* R. Br., nos. 1, 5
- Portulaca samoensis* v. Poelln., no. 23
- Cassytha filiformis* L., no. 7
- Hernandia sonora* L.
- Crataeva speciosa* Volk., no. 9
- Canavalia microcarpa* (DC.) Piper, no. 24
- * *Mucuna* sp.
- Vigna marina* (Burm.) Merr., no. 11
- Citrus aurantifolia* (Christm.) Swingle, (Lime)
- C. sinensis* (L.) Osb. (Large round green orange)
- Acalypha amentacea* var., nos. 19, 39
- Codiaeum variegatum* (L.) Bl.
- Euphorbia chamissonis* (Kl. & Gke.) Boiss., no. 8
- Manihot esculenta* Crantz
- Phyllanthus niruri* L.
- * *Triumfetta procumbens* Forst., no. 32
- * *Hibiscus tiliaceus* L.
- Thespesia populnea* (L.) Sol. ex Corr.
- Calophyllum inophyllum* L.
- Carica papaya* L.
- Cucurbita* sp.
- Terminalia samoensis* Rech., no. 6
- * *Barringtonia asiatica* (L.) Kurz, no. 4
- Psidium guajava* L.
- Polyscias fruticosa* (L.) Harms no. 28 (Cultivated as hedge plant.)
- P. scutellaria* (Burm. f.) Fosb. (Cultivated as hedge plant.)

Centella asiatica (L.) Urb., no. 35

Ochrosia oppositifolia (Lam.) K. Schum., nos. 17, 38 (No. 38 is sterile, determination doubtful.)

Plumeria rubra L.

Ipomoea batatas L.

* *Messerschmidia argentea* (L. f.) Johnston., no. 3

Clerodendrum speciosissimum Van Geert, no. 20

Asystasia blumei Nees, no. 26

* *Scaevola frutescens* (Mill.) Krause, no. 2

Wedelia biflora (L.) DC., no. 30

An unidentified seedling, no. 31



ATOLL RESEARCH BULLETIN

No. 22

Summary of Information on Atoll Soils

by
E. L. Stone, Jr.

Issued by

THE PACIFIC SCIENCE BOARD

National Academy of Sciences--National Research Council

Washington, D. C.

SUMMARY OF INFORMATION ON ATOLL SOILS

by

E. L. Stone, Jr.

Our knowledge of atoll soils is still fragmentary and the following relates particularly to wet atolls, which have been more extensively studied than dry atolls. The nature of atoll soils is closely linked to the geological material on which they formed. These soils are extremely immature, usually having A-C profiles dominated by calcium and magnesium carbonates and with texture but little modified from that of the original material. This immaturity is in part a consequence of their limited age, which is presumably less than that of the xerothermic period, and of the continual disturbance by storms and typhoons. The frequent rejuvenation by storms is one of the major features of the land surface. Thus there has been little soil development in the usual sense, and the characteristics of the well-drained soils, in so far as they differ from geological materials, are due chiefly to organic matter accumulation and associated chemical changes.

I General: Despite immaturity, the differences in soils and physiography are sufficient to give rise to a variety of habitats. The expression of these in the vegetation, however, is in part concealed by the limited flora. This sometimes leads to a specious appearance of uniformity.

II Physical Nature of the Parent Material: The primary sources of land material are, of course, the reef organisms but in at least a few instances foreign material may occur. On Rose Atoll basalt has been found and pumice has been reported common on a number of atolls.

The mode of land formation has been treated more fully by geologists and need not be repeated here although it is obvious that particle size distribution and elevation of the land surface strongly influence subsequent soil development. Frequently materials deposited along the seaward shores are coarse-textured and porous. Consequently, as the data of Cox indicate, the ground water lens may have a lower head and greater salinity on the seaward side as contrasted with the lagoon shore, which is commonly composed of finer materials.

Although differences in texture of the deposits affect ground water movement and plant growth, all are sufficiently coarse to be freely pervious to air and water. The moisture holding capacity of the mineral soil is low, increasing the effect of rainfall distribution and ground water. Where fresh water is available at shallow depths textural considerations obviously do not have the significance for deep-rooted plants that they often have elsewhere. Furthermore, it is probable that the porosity of weathered coral and reef rock increases their moisture-holding capacity, as compared with that of solid fragments of similar size.

III Chemical Nature of the Parent Material: Analyses of the reef organisms, as by Clark and Wheeler, indicate that calcium carbonate, while predominant, is by no means the only compound of importance in their composition. Some of the Lithothamnion group may contain up to 25% magnesium carbonate and some of the Foraminifera up to 11%. Although phosphorus is generally low, some of the Crustacea may contain up to 27% calcium phosphate in their skeletons and there are appreciable amounts in some of the Alcyonarian corals. Nine samples of non-phosphatic subsoils from Arno contain from .01 to .02% phosphorus. Soluble potassium is found in moderate amounts whenever appreciable exchange capacity is present. Traces of most elements are of course to be expected by reason of their presence in sea water.

As a source of plant nutrients these materials have certain apparent advantages and disadvantages. The calcareous medium tends to be favorable for some nitrogen-fixing legumes and Azotobacter. However, it limits availability of certain nutrients such as iron, of which there is a conspicuous deficiency whenever organic matter content in the soil is low.

IV Soil Formation and Properties: These can not be considered apart from climatic influences, particularly those of rainfall. Not only the amount but the constancy of rainfall is of prime importance, with the effect of variation being more drastic the lesser the amount. The effects of variation are of particular consequence on narrow islands where the nature of the ground water lens is more readily affected by short droughts. Rainfall obviously affects the composition of the ground water and the rapidity of leaching of salts formed in the soil and those added by spray. To date conductivity measurements seldom show sufficient concentration of salts in the surface soil to be injurious to the plants, although these do not represent the temporary conditions that may result from flooding or heavy spray during severe storms.

Mere descriptions and analyses of a variety of profiles are often of limited value until the soils can be classified and arranged into an actual or inferred sequence related to time or developmental stages. Many of the data for well-drained soils on Arno and Onotoa can be described by such a sequence:

It is evident that the initial development of vegetation is somewhat analogous to lifting one's self by the bootstraps; plant growth is required to create organic matter which in turn supplies nitrogen, renders certain nutrients available, etc., to permit additional growth. In the early stages following colonization by hardy plants, each gain in amount of organic substance tends to favor greater and more diverse vegetational development. Ultimately the extent of this development is reflected in the soil profile. Thus a sequence may be observed extending from the wholly unaffected beach sand or boulder rampart of the island margins to the dark surface soils beneath the lush vegetation of the island interiors. Although in any one transect such a sequence is usually associated with time of development, other factors such as exposure, rainfall, groundwater, etc., surely influence the rate and presumably the maximum stage of development attainable. The conventional soil type designations employed tentatively on Arno can be used to designate various bands in this hypothetical developmental sequence on moist atolls. Figure 1 shows some features of profiles representing successive positions in such a sequence.

Figure 2 illustrates the inferred sequence from shore to interior and the effects associated with increasing organic matter content. In the synthetic transect the Onotoa profile appears to agree generally with those from Arno atoll.

The consideration of organic matter is almost inseparable from that of nitrogen since the two are linked in the soil with an OM/N ration of between 20:1 and 30:1. Apart from growth effects, in the absence of nitrogen additions of organic substance alone do not result in formation of "humus" and hence organic matter accumulation. The very considerable accumulations illustrated by Figure 2 direct attention to the sources of nitrogen. Apart from rainfall four are known: (1) Flotsam and dead marine organisms are presumably of significance only to the early stages of strand vegetation. (2) Legumes, Sophora, Canavalia, and Vigna are often common in the earlier stages of the sequence but only Intsia persists in quantity in the dense forest. (3) The contribution of nitrogen-fixing blue-green algae is unknown although certain terrestrial algae are abundant. *Azotobacter* is common in certain Arno collections (Lochhead) and presumably would be favored by the highly organic calcareous substrate. (4) Observations suggest that sea-birds may add appreciable amounts of nitrogen to the land surface generally, apart from the marked guano or phosphate areas. High amounts of nitrogen and phosphorus found in sparsely vegetated areas on dry Canton Island are attributed to nesting birds (MacDaniels, Hatheway).

There are no systematic studies of organic matter decomposition but vigorous faunal activity by termites, snails, earthworms, crustacea, etc., (Ussinger and LaRivers) rapidly reduce organic residues. Incorporation of organic matter may also be accomplished by grasses and the dense root mat of the coconut. Well-drained atoll soils seem to be marked by a sharply delimited zone of mixing, with slight organic staining of the deeper layers only in the older profiles. Darker layers occurring at depth usually indicate profile burial, as by dunes, typhoon debris, etc. Deep profiles may originate by continuous additions, as of wind-blown sand to a vegetated surface, and probably also in certain imperfectly drained situations.

As indicated by Figures 1 and 2, the depth of the organic layer tends to increase with age but the most marked effect is in percentage composition. Rather rough estimates indicate that the dark soils from Arno contain at least 2,000,000 lbs. organic matter per acre. It appears likely that a few centuries may have been required for such accumulation and there is no evidence of any rapid decline in the long occupied areas of Arno Island.

In non-saline atoll soils reaction commonly ranges between pH 7 and 9, with the higher values presumably influenced by magnesium carbonate. Moderate but consistent shifts in soil reaction are associated with the effects of organic matter. Species unsuited to an alkaline substrate may be favored further by localized pockets of organic matter, decaying wood, etc., of lower reaction. A slightly acid reaction also characterizes some peats.

Of the mineral nutrients phosphorus occupies a special position because of the probable significance of sea-birds in the phosphorus cycle of land areas,

as well as in numerous localized accumulations. A possible role of phosphorus deficiency in the "laora" disturbance of coconut has been conjectured but evidence is as yet incomplete. An effect of copra cropping on phosphorus removal from the land has been suggested.

Fosberg's study of the ecological factors involved in phosphorus accumulation may solve a number of questions on phosphate "rock" and "hardpan", and perhaps on nitrogen accumulation in the dark soils also. In addition to their effects in situ, such deposits might well be reworked, notably enriching new beach materials.

Exchangeable (or extractable) potassium tends to increase with the exchange capacity of organic matter but it is markedly affected by leaching and by contact with salt water. Under dry conditions evaporation may concentrate potassium, as well as nitrate nitrogen, at the soil surface but the high values of such samples (e.g. Pikini) are not indicative of the entire soil.

Of the other plant nutrients calcium and magnesium are, of course, abundant, and little is known of the precise status of many "minor" elements. Iron deficiency is common in many plants, and symptoms on introduced plants suggest their susceptibility to other deficiencies.

Observations on soil organisms from Arno Atoll show appreciable numbers and the expected relationships between numbers and organic matter content. Determination of species and groups (Lochhead, Martin) indicate that the fungal and bacterial flora are cosmopolitan.

Losses from leaching can be assumed except on the driest atolls. Some recovery from the groundwater by vegetation is probable but is limited by the level of maximum evaporation, (presumably about 60") and the selectivity of plant roots. A continuing loss of calcium and magnesium carbonates is obvious but visible solution seems limited to the surface layers. Softening and reduction of large fragments is marked in the surface layers of the older soils.

Although the undisturbed well-drained type of profile is taken as a model, numerous exceptions and anomalies occur as a result of typhoons, shoreline activity, etc. Freshwater and mangrove peats, phosphate rock, exposed beach rock, etc. provide numerous specialized situations for vegetational development.

Students of atoll soils and ecology must add to their interest of vegetational succession a recognition of the frequent and drastic affects of catastrophe, of the influence of primitive man and his recent congeners, and of the self-limiting nature of many formative process.

The economic aspects of atoll soils are obvious, at least in outline. Within the limits set by climate, groundwater and exposure (as to spray) the productive capabilities and responsiveness of soils are set by texture, organic matter status, phosphate influences and perhaps by certain effects of age or history such as are associated with the "laora" disease. Many of these are subject to mapping, description or interpretation for use in any appraisal of atoll land productivity.

Figure 1.--Characteristics of Some Atoll Profiles

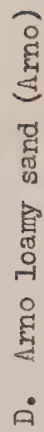
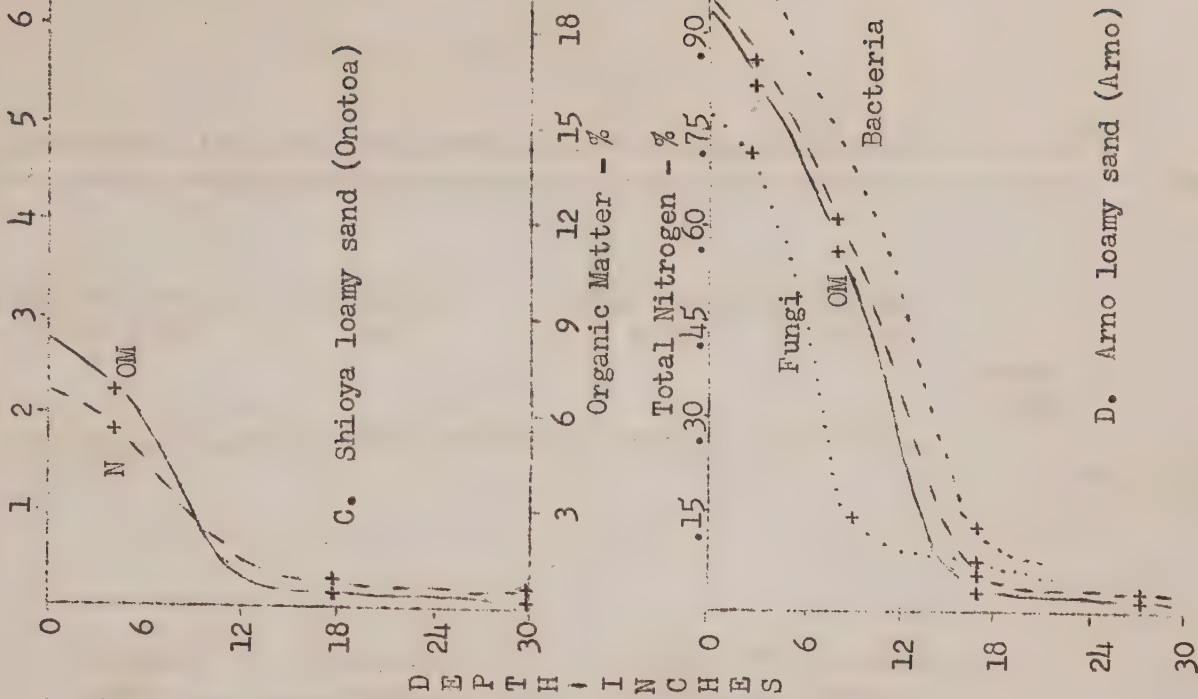
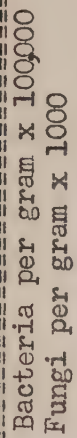
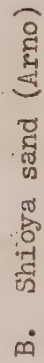
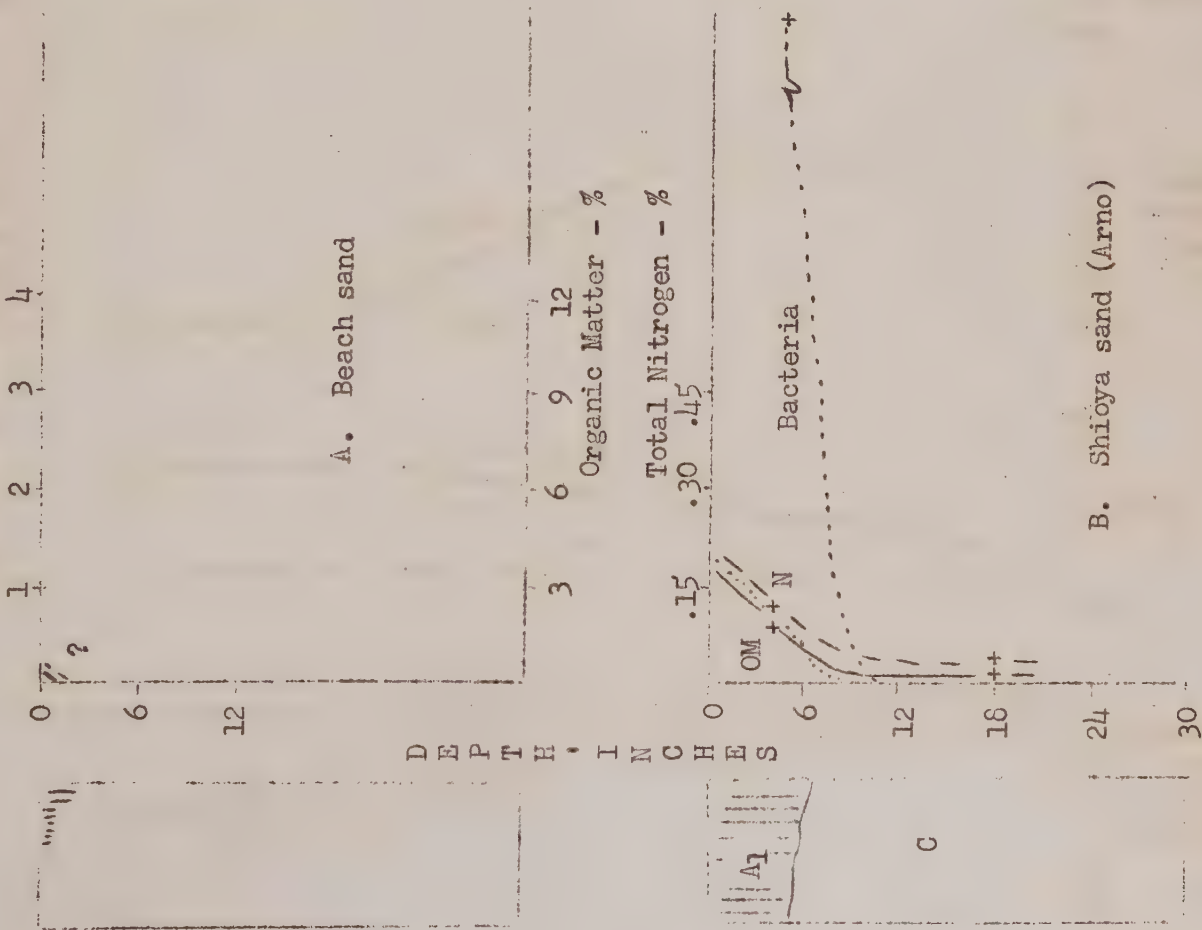
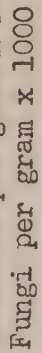
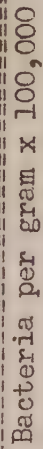
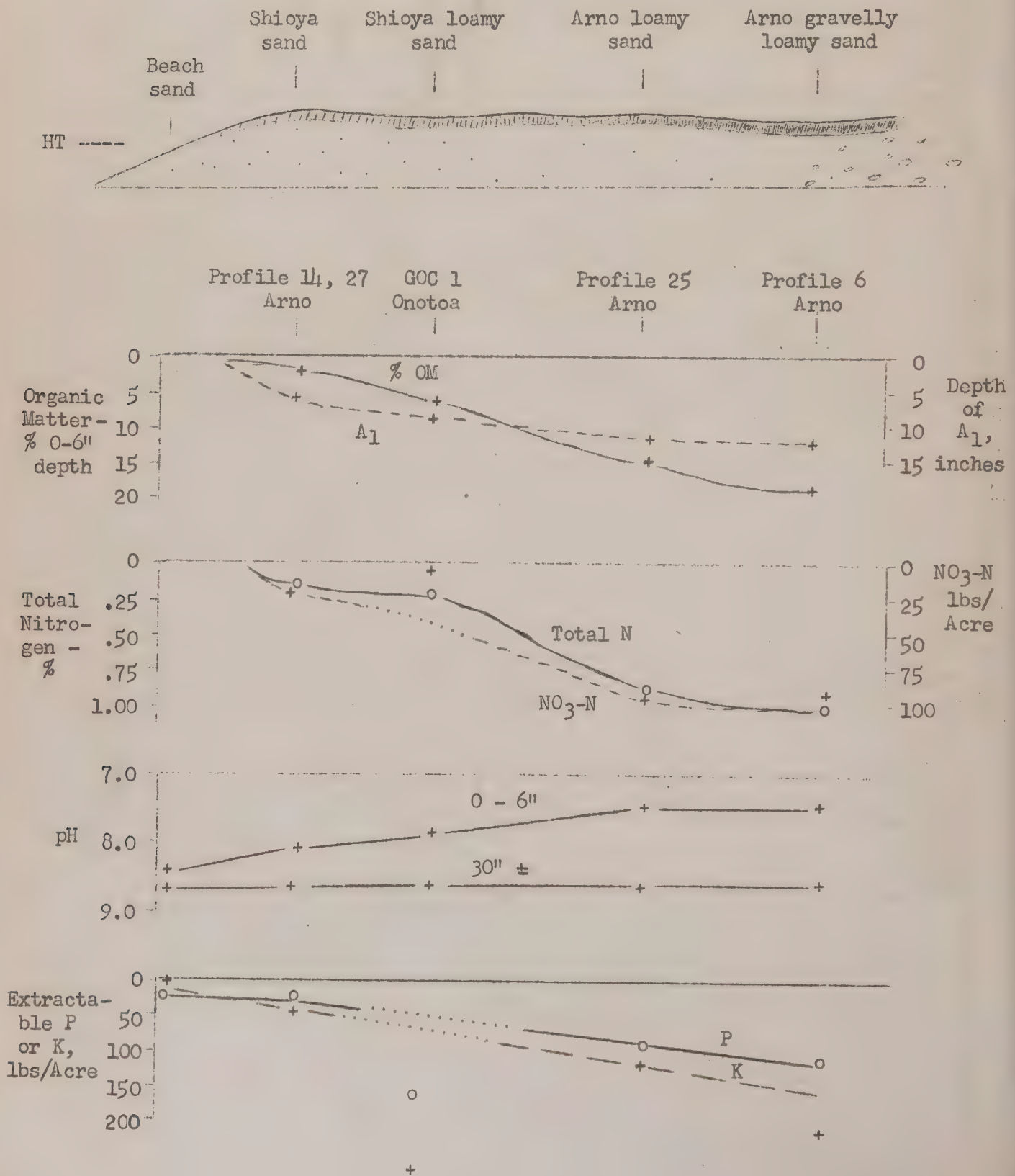


Figure 2.--Synthetic sequence of soil development and soil properties.



ATOLL RESEARCH BULLETIN

No. 23

Vegetation of Central Pacific Atolls, A Brief Summary

by
F. R. Fosberg

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Washington, D. C.

VEGETATION OF CENTRAL PACIFIC ATOLLS, A BRIEF SUMMARY¹

by
F. R. Fosberg²

¹ Publication authorized by the Director, U. S. Geological Survey.

² Geologist, U. S. Geological Survey.

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VEGETATION OF CENTRAL PACIFIC ATOLLS, A BRIEF SUMMARY¹

by F. R. Fosberg²

Introduction

One of the primary purposes of the meeting on Atoll Soils and Vegetation, held in St. Louis in December, 1952, was to summarize the results, insofar as vegetation is concerned, of the three Pacific Science Board atoll investigations, undertaken on Arno, Onotoa, and Raroia atolls, along with results of recent expeditions to the Marshall Islands by William Randolph Taylor and F. R. Fosberg. Formal papers were not prepared for this meeting, nor was a verbatim record kept of the discussion. It seems worth-while to briefly summarize what is known of Pacific atoll vegetation in light of the results of the St. Louis meeting and of other significant studies that have been made. No attempt will be made, however, at this time to digest the complete literature on the subject. Work is being done on such a project, but it will require much more time.

Unfortunately the reports on the vegetation of Onotoa and Raroia have not yet been submitted, so that the greater part of the following summary is based on studies in the Marshall Islands. The vegetation of some of these islands has been observed by Bryan in 1944, Taylor in 1946, Stone and Anderson in 1950, Hatheway in 1952, and Fosberg in 1946, 1950, 1951, and 1952. Detailed notes are available for Arno, Bikini, Eniwetok, Rongerik, Rongelap, Pokak, Bikar, Utirik, Taka, Ailuk, Jemo, Likiep, Lae, Ujae, Wotho, Ujelang, and parts of Kwajalein, with less satisfactory observations on Majuro, Jaluit, and Ailinglapalap. Fairly good information is available on Nomwin, Kapingamarangi, Nukuoro, Satawan, and Lukunor in the Carolines, also some on Kayangel and Pingelap. The only comprehensive modern study of atoll vegetation, other than those mentioned above, whose results are available, is that of Christophersen on the Whippoorwill Expedition in 1924 (Christophersen 1927). Incidental to other work some notes on vegetation on the southeastern Pacific and a few central Pacific atolls were made by St. John and Fosberg in 1934 and on Christmas Island by Fosberg in 1936. Only a few of these are published (St. John and Fosberg 1937, Fosberg 1937, Fosberg and St. John 1952). Hatheway investigated Canton Island on short visits in 1950 and 1951 and prepared an account that is still unpublished.

The Atoll Habitat

Atolls are reefs of organic limestone that are partly, intermittently, or completely covered with water, and on which there are islets or islands made up of accumulations of limestone debris, loose or consolidated, and occasional remnants of former higher reef surfaces. These islets are usually not more than two or three meters above high-tide level, sometimes

¹ Publication authorized by the Director, U. S. Geological Survey.

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much less than this; occasionally storm-built rubble or boulder ridges and wind-deposited dunes rise to somewhat higher elevations. The highest of these wind-deposited features is Joe's Hill, a dune on Christmas Island, which is variously reported to be as much as fifteen meters. Where the surface of these islets is more than a few dm. above mean tide level the drainage is perfect, down to this level. From a few cm. above mean tide to somewhat below it, lens-shaped bodies of fresh to brackish ground water lie in the porous material of the islands, floating on the surface of the salt water which otherwise permeates these structures and held there in equilibrium by friction with the solid material.

Since the atolls are practically entirely within the tropics, and also are surrounded by water, there is not much temperature variation. Rainfall and winds, however, show quite a diversity. Rainfall ranges from extremely scanty in the belt of atolls along the equator and in the northern Marshalls and southern Gilberts to very heavy in the southern Marshalls and Caroline atolls. Most of the atolls, of course, have a moderately wet climate. In some, though the total average rainfall may be moderate, the erratic precipitation makes the total figures give a false impression. Also, the porous nature of the substratum makes comparison with regions of ordinary soil difficult. For example, Pokak Atoll, with rainfall comparable to that of parts of the eastern United States, has the aspect, vegetationally, of a semidesert. Winds are important in three main respects. The drying power of a steady fairly strong breeze, even after it has blown over the sea for great distances, is extreme, and the effects of wind on the vegetation in the trade wind belts are very obvious. It is never difficult to tell which side of an atoll islet is the windward side, as the vegetation is commonly "wind-sheared" (probably more correctly spray-sheared in many cases) in an inclined plane down to the top of the beach. On the leeward side the edge of the vegetation is usually perpendicular or rounded. The salt carried in spray by winds undoubtedly has a very important effect on the vegetation. There have been no actual measurements of this, either as to quantity or effects, however. The absence or rarity of certain species of plants on the windward sides of islets in windy belts may very well be due to this salt accumulation. The third climatic factor of great significance is the occurrence of typhoons or hurricanes. These powerful storms create and destroy land, drench the land with salt water, remove vegetation, modify it, and indirectly affect it through changing the human population. They create a type of long-term instability of the habitat that is reflected in the character of the vegetation in several ways which are apparent to the observer, but which must be studied more critically than they have yet been to be understood. In some of the Marshalls, considerable areas have been denuded of their vegetation or most of it by relatively recent typhoons.

The age of these islands is an important consideration, ecologically. It is possibly ascertainable, within certain limits, through knowledge of the relatively recent eustatic fluctuations of sea level, though there is some difference of opinion on both the time and nature of these fluctuations. The current idea seems to be that a period of higher levels, perhaps two meters above the present stand, occurred several thousand or up to five thousand years ago, during the so-called post-glacial "xerothermic period" or "climatic optimum." If such a higher sea level did exist, it might not

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be necessary to regard ecological reasons only, as responsible for the impoverished floras of coral atolls. It may well be that dry land did not exist on most atolls at that period, and that these floras have come into existence through accumulation of chance seaborne and airborne colonists in a period as short as five thousand years.

In the biotic environment, sea-birds, land-crustacea, and man are the three most conspicuous groups and probably the most important, ecologically. The birds played a most important part in making the habitat favorable for plants and in maintaining it so, by additions of phosphatic and nitrogenous material, until they were driven away from most places by man. Land crabs and hermit crabs, present in myriads on most atolls, promptly reduce organic matter of most sorts to soil, tending to make the habitat suitable for other than the most extreme pioneer species of plants. They must also play an important role in mixing soils, because of their burrowing habits, bringing up deposited and unaltered materials and burying vegetable debris (Wood-Jones, 1910). Dr. Otto Degener (conversation, 1950) contends, also, that the hermit crabs are important in devouring seedlings of plants and thus impoverishing the vegetation. This has not been noted by other investigators, though they have been seen occasionally eating leaves from living plants. Man has, ever since his arrival, been an extremely destructive agent, especially toward indigenous forest vegetation. He has, of course, replaced it with coconut and breadfruit plantations and their attendant weed species; he has contributed a host of exotic weeds; and he has upset the phosphate balance both by driving away the sea-birds and by exporting untold quantities of copra, which has a high phosphorous content. He also, in many places, burns the organic matter which would ordinarily go to build up the soil. Where he exists in large populations, he may reverse these processes to some extent by composting and fertilizing.

Colonization by Plants

Plant seeds may be brought to an atoll islet by water, wind, on the feet, plumage, or in the stomachs of birds, or by man, accidentally or deliberately. One case has been observed by Dr. Kenneth Emory on Kapingamarangi of a portion of a tree drifting ashore while still alive and taking root. An examination of the floras indicates that, before the coming of Europeans, the water was probably much the most effective means of transport. Most of the plants possess adaptations for floating their seeds across even large expanses of water.

The plants that make up almost the entire indigenous floras of atolls are those that constitute the strand floras of high islands, continents, and other coral islands, and they are mostly very widespread. There are very few species confined to or even principally found on atolls.

Contrasted with the probable situation on high islands, successful establishment of transported plants on atoll islands is a very frequent affair. Abundant seedlings from drift seeds may be seen during almost any walk along the beaches of an atoll. These are, of course, mainly the same series of pioneer species, over and over again. The following species were

seen as drift seedlings in the northern Marshalls:

Abundantly establishing themselves in drift:

Messerschmidia argentea
Scaevola frutescens
Lepturus repens
Guettarda speciosa

Rather frequently seen:

Pandanus tectorius
Portulaca lutea (in drift situations but not positively of
drift origin)
Triumfetta procumbens
Vigna marina

Rarely seen in drift:

Cocos nucifera	Barringtonia asiatica
Ipomoea pes-caprae	Suriana maritima
Hernandia sonora	Terminalia samoensis
Calophyllum inophyllum	Wedelia biflora
Intsia bijuga	Ipomoea tuba
Morinda citrifolia	

Seen as seedlings, once each, but never seen to persist:

Caesalpinia majus
Caesalpinia crista

A number of kinds of seeds frequently drift ashore but were not seen germinating. Among these were Entada and several species of Mucuna.

Although not directly observed, colonization by many other species unquestionably takes place. Many species do not seem to be able to survive on open beaches and bars, but need either the protection from wind and salt or shade from the sun provided by already established vegetation or the presence of at least a small amount of humus in the soil. Some deeprooted species doubtless require a certain degree of freshness in the ground water. The species that require the presence or influence of other plants, as well as those that need fresh ground water, are commonly found in the interior of islets, though they often may be much nearer the lagoon than the seaward beaches.

How their seeds are carried to such situations is not always apparent. Unquestionably Pisonia is carried around by birds. Its fruits are exceedingly sticky and a noddy (Anous) was seen on Wotho literally plastered with them. Several species of birds seem to prefer to roost and nest in Pisonia trees. Boerhavia and Peperomia, as well as Adenostemma, also have sticky fruits and may be transported by birds. Cassytha and Pipturus have small fleshy fruits, which doubtless are eaten by birds and the stones transported in birds' stomachs. Which birds would do this is not demonstrated. Scaevola is, without question, carried around in this way in addition to floating, as the droppings of curlews were seen to be commonly packed with the stones of this plant. Ximenia might be carried in the same way, though its fleshy fruits

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are quite large, resembling small plums. Another aspect of this, not previously suspected, was discovered on Arno by Marshall (1951). He found in the stomach of a fairy tern (Gygis) the seed of Ipomoea pes-caprae, a plant not even growing on Arno, but common on Majuro, a few miles away. Why the bird had eaten this is not apparent, as terns are fish-eaters. Perhaps the seed was picked up to serve as a gizzard-stone. Wind doubtless accounts for some small-seeded species, but there are few indigenous atoll plants that seem especially adapted for this method of transport, except the ferns, mosses, and other cryptogams. Plants with floating fruits or seeds, such as Ochrosia, Thuarea, Cordia, and the ones mentioned above as pioneer species, since they may be found growing back of or far from the beach, must sometimes be carried inland by storm waves, as is the occasional pumice found scattered on the ground surface far inside the beach. Man must not be disregarded as an agent of distribution, even of apparently indigenous plants, as well as of his cultivated ones and camp-followers. Sida fallax is planted about houses in the Marshalls and Carolines, as well as growing wild. Evidence seems to be accumulating that the mangroves, at least Pruguiera, found in landlocked pools and muddy depressions have been deliberately introduced and planted by the Marshallese. And in addition to planting the various obviously useful and ornamental plants, the Gilbertese, at least, (Luomala m.s.) pick up and plant any seeds that happen to be cast up on the beach. A further influence is exerted by man in the creation of habitats for species which otherwise might seldom find a place to get a foothold. Such are especially the taro-pits, dug down to ground water and filled with vegetable muck. Several weeds, such as Eleocharis, Cyperus, Jussiaea, and a number of ferns are found only or usually in such situations. The coconut plantation is also a rather special habitat and may, at least, give some plants enormously more opportunities or "lebensraum" than they normally would have. Willis and Gardner (1901) give a much more comprehensive discussion of these matters for the Indian Ocean atolls.

Little is known about the reasons for the small numbers of species in atoll floras. These range from three (Christophersen 1931, Fosberg 1937) to perhaps 150 in Pacific atolls and as many as 284 (Willis and Gardner 1901) in those close to continents as the Maldives in the Indian Ocean. Distance from sources of colonists and the effectiveness of the ocean as a barrier are obviously of primary importance. Shortness of the history of land availability on atolls may well be another consideration. The scarcity of endemic species results from this. Lack of topographic or altitudinal diversity is another obvious factor. However, the difficulty in getting many of the commonly tried cultivated species to grow in these islands and the large number that simply will not grow there, at all, point to the importance of edaphic considerations, though these have not been much analyzed as yet. Salinity and the highly calcareous nature of the soils are two unquestionably controlling factors. Such observations as the distribution of species in relation to ground and aerial salinity, the death of breadfruit trees where washed by typhoon waves or where the ground water becomes saline (Cloud 1952), and the native practice of leaving a protective strip of forest on the windward sides of coconut plantations are at least indicative in this direction, though systematic studies remain to be done. Certainly one of the most striking systematic variations observed is the increase in number of species from atolls with a dry climate to those with a wet climate. Pokak and Bikar,

in the dry extreme north of the Marshalls, have 9 species of vascular plants each, while from Arno, in the wet south of the same group are recorded 129 species (Anderson 1951, Stone 1951). This discrepancy is not due to inadequate collecting, as Pokak and Bikar have been very thoroughly examined. Any further collecting may result in increasing the difference, as more plants may possibly be found on Arno while this is not likely on the others. There are doubtless other limiting or controlling factors and combinations of factors influencing the sizes and compositions of atoll floras, but to discover and understand them will require further study and further correlation of available information.

Succession or Vegetational Change

No coral atoll has had sufficient study for even the principal vegetational successions to be well known. No single succession, from bare ground to a relatively stable vegetation, can be described in anything like a complete fashion. Only locally are relatively stable (climax) vegetation types known with certainty. But it is possible to outline, however roughly, some probable successional trends, and to point out with some confidence certain successional relationships that are more than accidental. In this paper any change in vegetation that seems to proceed in a definite direction is regarded as a succession. This is in contrast with fluctuations around a point of equilibrium. And if the latter, over a period of time, result in a directional change in the equilibrium, that also is regarded as a succession. Such changes as are known or suspected are described below under several categories.

1. Usual development of vegetation:

As noted above, under Colonization, bare sand and gravel bars are soon covered by seedlings of a small number of pioneer species. These are able to stand full and very bright sun and high salinity, also considerable dryness. Of these, a large proportion are tree species, and, in an ordinary mixed stand of pioneer species, many will be trees. In most sites scrub is the first vegetation to appear, and if tree seedlings form an important component, these soon overtop the others, developing a low forest. Growth, even under quite dry conditions, is extremely rapid. On Wake Island, with an annual rainfall of 650-1370 mm., Messerschmidia has been observed to grow almost two meters in a year. The simplest forests thus formed are pure stands of Messerschmidia, mixtures of Messerschmidia and Guettarda alone, or with Pandanus tectorius and a varying smaller proportion of a number of other trees. Terminalia samoensis, Intsia bijuga, Barringtonia asiatica, and possibly Cordia subcordata are pioneer species and may make up a part of the original composition of such a stand. There is no doubt, however, that they, as well as Guettarda and Pandanus are also capable of increasing in number in mixed stands. Pisonia grandis, Allophylus timorensis, Pipturus argenteus, Soulamea amara, Ochrosia oppositifolia, and other species are, so far as known, added only after the original stand has become established and usually after it has assumed the character of forest. The resulting mixed forest is the commonest type of native forest existing in the Marshalls today. The same type apparently develops following clearing by man. In the northern Marshalls there is no particular pattern in the arrangement of

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species in this type of forest, but Hatheway (1953) reports that in the southern Marshalls the trees commonly occur in small clumps or groves of a single species.

The shrub and herb species present in the original stand persist for a long time in these forests as undergrowth and ground cover. Eventually, however, they may be almost entirely eliminated. Lepturus, curiously enough one of the first and most abundant pioneers to appear, often persists longest, forming a thin grass ground cover in all but the most dense mixed forests. With it is usually Thuarea, which was not seen as a true pioneer on new habitats in the northern Marshalls. Fimbristylis, also one of the pioneers, often persists a long time, especially if the canopy is not too dense. Wedelia and Ipomoea tuba may persist a long time, the latter probably becoming more abundant as time goes on. It is an important part of the canopy in many mixed forests. In rocky places Fleurys ruderalis persists a long time if the canopy is at all thin.

Whether this mixed forest ever reaches stability is not known. Its widespread occurrence suggests that it may, as does the structure of the most mature and well-developed stands, with large trunks, dense canopy, thin or absent undergrowth, and seedlings of some of the dominant species. It seems certain that Messerschmidia, one of the most abundant early constituents, drops out after one generation. Healthy seedlings of it are never seen in full shade, and when it is present in a very well developed mixed forest the trees are all old and very large. Messerschmidia logs are often seen lying in this type of forest where there are no living trees. Observation of Pisonia, with its habit of sending up root sprouts and of usually taking root wherever it touches the ground when blown down, suggests that it may gradually take over mixed forest if left long enough. Common occurrence of pure stands of Pisonia may be due to this process. These may, however, result also from colonization of Pisonia in Lepturus grassland, as seen on Pokak Atoll. This might more commonly be the case on drier islands, where stands of Lepturus, or Lepturus and Sida fallax often persist for a long time.

There seems little question that, at least under conditions of moderate rainfall, such as in the central Marshalls, Ochrosia oppositifolia may eventually dominate mixed forest once it gets started, and often will take over completely, forming extensive pure stands. The best areas seen of this type are on Wotho Atoll, but it is a common occurrence on Lae, Ujae, Kwajalein, and Erikub, at least. There is good evidence that it will eventually crowd out even Pisonia. Pure stands of Ochrosia are relatively permanent and stable as shown by the normal occurrence of a dense ground cover of seedlings several dm. tall, which shoot right up if even a little light is available. One puzzling circumstance about these stands of Ochrosia is the presence of persistent yellow spots, seen in the same locations on photos taken in 1944 and on the ground in 1951. The trees are chlorotic and in some cases there are a few dead ones, and in these places Allophylus and even other trees seem able to come in. There is no obvious difference in soil or other environmental factors in these spots.

Frequency of pure stands of various species is a peculiarity of atoll vegetation, at least in the northern Marshalls; pure stands of Pandanus and Pisonia and perhaps others are also found in central and southeastern Polynesia. How this is related to the general successional picture is not

apparent, except perhaps in the cases of Pisonia and Ochrosia. These and at least some of the other pure stand types may very possibly be end stages of successions under certain conditions. This is certainly not the case, though, with such pure stands as those of Lepturus, Portulaca, Scaevola, Messerschmidia, Pemphis, and other strictly pioneer plants. Pure Pandanus forests, while rare in the Marshalls, seem to occur more commonly in the Tuamotus, also on Maria Atoll, Austral Group. Their origin is a matter of great interest and curiosity.

On bare rock, especially rough conglomerate or pitted beach rock, Pemphis acidula is ordinarily the first plant to appear, though actual seedlings colonizing such habitats have seldom been observed. Hatheway (1953) says that small pockets of sand on such rock surfaces are the seed beds for this species. Once established on rocky places, these trees persist, often or usually in pure stands, even where their roots are bathed in pure sea water at high tide. Such stands were not observed to be succeeded by anything else.

2. Effects of catastrophe and instability:

Natural catastrophes on coral atolls are mainly of two sorts, typhoons (hurricanes) and tsunamis (so-called tidal waves). The former are, of course, much more frequent than the latter, and their frequency varies much more in different parts of the world. Typhoons are almost unknown, for example, in the Gilberts, somewhat more frequent in the Marshalls, and common in the western Carolines. Statistics on typhoon incidence would be very valuable in interpreting vegetation differences.

Both typhoons and tsunamis are capable of sending salt water completely over atoll islets. There are apparently no actual records of the effects of tsunamis on atolls, but they have poured water onto high island shores to a much greater height than the total altitude of most atolls. Certain plants would undoubtedly be killed by this, but few facts are available. Breadfruit, at least, has been observed to be so killed by salt storm waves (Cloud 1952).

Typhoons, in addition, commonly uproot trees of all sizes. They defoliate trees both by actually tearing the leaves off and by "burning" them off by driven salt spray, and perhaps by drying at the same time. They profoundly alter both the character and topography of the substratum, and change the actual outline of islands. Large areas of land surface on Arno Atoll were actually removed during the typhoons of 1905 and 1918, vegetation and all. Some of these places have been extremely slow to becoming revegetated. In others Pemphis has taken over effectively. There is no doubt that, in many areas, instability of substratum owing to typhoons is a major ecological factor in the determination of the character of the vegetation. Even where trees are not actually blown down, soil may be removed from around their roots, or rubble or sand may be piled up around the bases, smothering smaller vegetation and possibly eliminating certain larger species. Trees blown down make openings in the canopy in which species may appear that cannot establish themselves in its shade when unbroken. Defoliation of the canopy may allow temporary undergrowth to come in.

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Effects of typhoons on the vegetation are quite evident to the observer on most atolls, but a careful assessment of these effects has not been attempted, at least in recent times. Considerable information is recorded, but most of it by casual and nonbotanical observers. The thing that is most lacking is an actual eye-witness account, by a botanist, of a severe typhoon on an atoll. Accounts by others are usually conflicting and show evidence of very unreliable observation.

Effects on the vegetation maintained by man are sometimes recorded. The coconut trees were removed, along with the rest of the vegetation, on Arno in the typhoons mentioned above. Hundreds of coconut trees were blown down on Utirik, and many on some of the other atolls in the Marshalls, especially Aur and Maloelap, by "Typhoon Georgia" in March 1951. Likiep was completely devastated and apparently rendered temporarily unfit for human habitation by a typhoon sometime after the middle of the nineteenth century. In German colonial literature are many accounts of natives on the Caroline atolls being moved because their islands were rendered temporarily unable to support them by typhoons. One of the important effects was the filling in of taro pits with sand and salt water. Many accounts of hurricanes in the Tuamotus exist, but they give very little information on the effects on the vegetation. In places, however, the coconut groves were actually swept away.

3. Effects of climatic fluctuations:

Although there are atolls with the same annual rainfall with and without pronounced yearly dry seasons, no comparisons have been made of their vegetation. So the effect of simple annual fluctuation is not known. It would probably result, at least, in less epiphytes and a smaller total flora, probably in less overall luxuriance. Pisonia and possibly some other trees would show brief defoliation during the dry season. A strong dry season in 1951 in the northern Marshalls showed in some places partial defoliation of some other trees, such as Cordia and Terminalia. Whether this was normal or only the result of an extreme fluctuation is not known. The general aspect of the more northern atolls during this particular season became quite drab, where a few months earlier it was green.

In many atolls, especially those just south of the equator--the southern Gilberts, Phoenix, Howland and Baker, Jarvis, and Malden--one of the most potent factors influencing the vegetation is the extreme fluctuation in rainfall from year to year. Sometimes more than a year may elapse with no rain at all. In other times, more than the annual average may fall in one month. Under such conditions the general aspect is much drier than the average annual rainfall would suggest. And the luxuriance may vary so much from time to time that descriptions written several years apart scarcely sound as though the same island were described. Canton Island, in the Phoenix Group, has been described as having a general growth, principally Sida fallax, up to two m. tall during a wet period, but when visited in 1949, seven or eight years later, it had the aspect of a desert. On islands with large populations of sea-birds the injurious effects of high concentrations of guano seem to be greatly accentuated by these severe dry periods. Trees may be severely damaged or even killed. This has been seen on Pokak, in the Marshalls, Canton, in the Phoenix, and Christmas Island.

The theory, advanced by Hutchinson (1950) that phosphate deposits on islands that are at present wooded indicate a major shifting of climatic belts in the recent geologic past, so that these islands would have formerly been barren, does not seem in any way justified by the facts. Phosphate is formed on these islands at present under forest conditions, and only under such.

4. Changes caused by Man:

Alterations by Man's activities have affected the vegetation far more profoundly than typhoons, droughts, or any other natural phenomena. These have occurred in the Marshall Islands in three stages, the pre-European Marshallese period, the copra commerce period, and the Second World War. Comparable periods, or variations of them, have occurred on many other atolls. On some of the drier ones the copra commerce period has been replaced by a guano-digging period. On many the war had little or no effect. On a few, such as the Line Islands, the pre-European period was omitted, as the atolls were not inhabited when discovered by Europeans.

After the arrival of aboriginal man, the process of clearing the forests began. It could never have been very extensive, on most atolls, because of the lack of metal for clearing tools. It is probable that Pisonia forest may have been the principal type cleared, as the wood of Pisonia is soft enough to be cut by shell or stone implements. It is also possible that there was actually not much clearing, because coconut and breadfruit trees could be grown in the forests without clearing. In the case of the coconuts, at least, it might take longer for them to reach bearing age. Breadfruit, in wet climates, can shade out practically anything else likely to be found on atolls. In any event, there were probably over the centuries, fairly substantial areas dominated by coconut and breadfruit groves. Hatheway (1953) has estimated that in pre-European times perhaps fifteen percent of the land area was given over to agriculture. A part of this, on most Micronesian atolls except the driest, was used for taro pits. Marshy and swampy places were probably used for this purpose at first, then enlarged and enriched by addition of vegetable refuse. A few weeds probably came with the aborigines, as well as ornamental, medicinal, and food plants. The principal food plants brought along were coconut, breadfruit, several taro-like plants, possibly Tacca, and possibly Pandanus, though it is probable that at least some varieties of Pandanus were on most atolls already.

The drier atolls were probably mostly never permanently inhabited. Most of them were not when discovered by Europeans, though some showed signs of former habitations. Populations on the more favorable atolls varied, and the intensity of utilization of the land fluctuated accordingly. Typhoons, warfare, and losses at sea probably prevented overpopulation. If these failed, migration solved the problem. The more resistant types of forest and the less productive parts of the islands were probably not much disturbed.

With the coming of the Europeans this changed drastically. The demand for copra and the introduction of axes and machetes of steel caused the rapid replacement of the larger part of the native vegetation by coconut plantations, except on the driest atolls. And on these, enormous quantities of guano were dug up and exported, altering the vegetation, though it is

not easy to know how much. On the wetter atolls coconut plantations so completely dominate the vegetational picture that, ordinarily, coconut forest is regarded as the natural vegetation of such islands. It is, indeed, hard to dispel the idea that the coconut is indigenous and the dominant tree in the natural vegetation of these South Sea Islands. Now it is mostly the smallest islets, the exposed or very narrow ends of islets, and the seaward strip on the windward islets which show any native vegetation at all.

This change vastly increased the available habitat for some native plant species, however. Some of the undergrowth and ground cover plants, such as Euphorbia chamissonis, Clerodendrum inerme, Thuarea involuta, Fimbristylis cymosa, and Wedelia biflora, as well as such second-story trees as Pipturus argenteus, Morinda citrifolia, and Pandanus tectorius found this new habitat much to their liking and are now characteristic of such situations. Now, on fairly moist to wet atolls, dense undergrowth soon develops into thickets that choke the plantation. Keeping the plantations free from undergrowth is a major item of labor in this form of agriculture, even greater in places than harvesting the crop. Many new weeds and a few new cultivated plants, mostly ornamentals, came during this period. Papayas and bananas existed in many atolls previous to extensive coconut plantation, and were brought to others subsequently. Papayas, of course, are American in origin and did not exist in the Pacific prior to early European voyages. Most of the weeds are commonest around villages and paths, but some are ubiquitous, especially in plantations.

Long-continued harvest and export of large quantities of copra are beginning to show their effects. One of these seems to be phosphate deficiency, probably the cause of the gradual dying out of sizable areas of coconut plantation in the Marshalls. Similar symptoms are found in other regions.

Another effect of copra economy in some areas, notably the northern Marshalls, has been the abandonment of taro culture. Throughout the northern Marshalls there are extensive evidences of former taro pits that have not been used for many years. This phenomenon is most marked in what were probably the marginal areas of taro culture but is becoming evident also in the southern Marshalls, where both Colocasia and Cyrtosperma, the two taro-type plants grow very well. The culture and utilization of Tacca, also, has been almost abandoned in many islands, except when, after a typhoon, there is no copra to trade for rice or flour. Tacca, however, is still abundant as a spontaneous plant in the coconut groves in many atolls.

The war profoundly affected many of the atolls, especially in the Marshalls, Gilberts, and the central Pacific. Actual war, with the complete or partial destruction of the existing vegetation, took place on some islets of such atolls as Tarawa, Funafuti, Majuro, Kwajalein, Eniwetok, Wotje, and Wake Island. Here, in many places, were produced completely bare areas. These were soon covered by a blanket of Ipomoea pes-caprae, Vigna marina, Wedelia biflora, Pluchea odorata, Cenchrus echinatus, and other weeds. The Ipomoea and Wedelia in many places formed such a heavy mat that little else was able to gain a foothold, and many of the other weeds were smothered out. In other places Messerschmidia, Scaevola, and other pioneer woody plants

quickly became dominant. Only in relatively dry islands, such as Wake, has anything like the original vegetation come back. There Messerschmidia, Pemphis, and Cordia were the principal original woody plants, and in 1951 these dominated the scene again, in spite of almost complete obliteration in 1941-1945.

Another effect of the war was the construction of huge military establishments, especially air fields, on many atolls, even completely outside the area of actual military activity. This commonly involved complete destruction of vegetation. The bulldozer scraped the land clean, destroyed what soil had been developed, and smoothed down all topographic irregularities. Afterward, when the absolute desolation of such establishments became apparent, attempts were made to reestablish vegetation and to landscape these bases. Many of these have since been abandoned, but some are maintained and have even been extended and developed.

A further effect, though localized, has been the utilization of the atolls of Eniwetok and Bikini for testing atomic weapons. The effects of this were undoubtedly both destructive and otherwise. Although the bombs destroyed some areas of vegetation, these atolls had their native populations removed, and revegetation and succession have been able to proceed in most areas undisturbed. Some studies of these effects have been made, but no results have, as yet, been released, subsequent to the publication of the surveys made prior to the tests.

A great number of additional weeds have been introduced and spread during and since the War. Some of them, such as Pluchea odorata, Pluchea indica, Paspalum conjugatum, and Chloris inflata have been very aggressive, and have covered large areas in a short time. But over a period of a few years it has become evident that Wedelia biflora and Ipomoea pes-caprae will in most situations dominate and probably eventually smother out all of these, if disturbance is not continued. Another interesting point is that evidence points to the probability that Ipomoea pes-caprae is an introduced plant, at least in the Marshall Islands. Previous to the war it was only known from Jaluit, the headquarters of German and Japanese occupations. Now it is abundant in Kwajalein, Majuro, and Eniwetok, all sites of extensive military activity. This point has not yet been investigated for other Pacific atolls, though much evidence is available.

Probable future effects of man on the vegetation are hard to predict accurately. Undoubtedly populations will increase, and any available land will be planted to coconuts. This will not be much, however, as most of it is used at present--if it will raise even poor crops of nuts. Programs for economic development of coral atolls are under way and will unquestionably take the form of attempts to improve and extend agriculture. Attempts will likely be made to introduce new agricultural and horticultural plants, some of which might possibly be successful. New weeds will doubtless come in. There will unquestionably be further and accelerated vegetational change, most of it destructive to what little native vegetation is left. It is important that sample areas of all existing types be set aside for continued study. It is also very important that much more extensive general surveys be carried out to describe what is left before it is too late.

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Principal Types of Vegetation and their Variations.

Short descriptions of the principal vegetation types that have been recognized as occurring repeatedly or over large areas on Pacific atolls follow. The account is based again largely on studies in the Marshall Islands, but with the little available information from other areas brought in wherever possible. Some types that are conspicuous are treated here as variants of a widespread Mixed Forest type, as they really seem to be extremes of a rather continuously varying association of trees that characterize ordinary atoll habitats. Some of the kinds of vegetation described below have definite habitat relations and also successional relations with other types. These relationships are pointed out briefly and brought out again in the following section, where the pattern is integrated as far as is possible with present knowledge.

1. Coconut groves and plantations:

These are artificial forests of coconut palms planted, often in geometrical arrangement, five to six meters or less apart. In moist areas the crowns touch and interlace, forming a rather complete canopy; in drier places, they are well separated. In height an old plantation may reach an average of 25 m. The ground cover is varied, usually Lepturus, Thuarea, and Fimbristylis are fairly general in pure stands or mixtures, with Polypodium scolopendria, Tacca, Cassytha, Boerhavia, Fleurya, and other herbs locally common, extensive patches of Euphorbia chamissonis, Clerodendrum inerme, and Triumfetta procumbens, as well as mats of Wedelia biflora, Ipomoea tuba, Vigna marina, and Canavalia microcarpa. Pandanus, Morinda, Premna, Pipturus, Guettarda, and other trees may form a scattered understory, or, if clearing out of the undergrowth has not been kept up, these with Wedelia, Ipomoea, and Canavalia may form a dense tangled thicket, in which seedling coconut trees are likely to be quite abundant, making walking almost impossible. Breadfruit trees are often scattered through parts of the plantation near villages.

2. Breadfruit groves:

Although breadfruit (Artocarpus altilis) trees are commonly seen around villages and scattered in coconut plantations, in the wetter atolls especially in the Carolines and southern Marshalls are areas completely dominated by them. These groves are commonly made up of enormous trees, towering even above the coconut palms and with dense crowns that form a complete canopy through which very little light penetrates. On the floor of such a forest few other plants can survive. Seedlings of Morinda citrifolia occasionally maintain themselves where conditions are not too extreme, and in the Carolines an as yet undetermined species of Piper may form a mat on the ground. Several ferns are also occasional in such situations. Varieties of breadfruit both with and without seeds are present in these forests, the latter being undoubtedly originally planted by man. Both may increase by root sprouts, but the seeded varieties spread very readily by seed. Seedlings may be abundant beneath the parent trees if the light is not too scanty. The possibility should be investigated that these may occasionally be pollinated by seedless trees, and that some seedless ones may be offspring in this way of the seeded varieties. The trunks of large breadfruit trees may be two or three meters in diameter and unbranched to a height of 10 or 15 meters.

3. Mixed forest:

The most generally distributed native forest on coral islands is a variable mixture that, in one place or another, may include practically all tree species found on atolls. It is, in fact, so diversified that its principal common feature is that it is a mixture. It usually includes, among its components, Pandanus, Guetarda, Pisonia, Messerschmidia, Intsia, Cordia, and Ochrosia, frequently, also, Terminalia, Allophylus, Soulamea, Hernandia, Barringtonia, Pipturus, and Ficus. This I have called Mixed Forest. Hatheway 1953 calls it Scrub Forest, which term is often appropriate, as its stature varies from scrub to tall forest 25 m. high. In density it varies from close enough to form a complete canopy to sparse and open. If sparse, there is ordinarily a tangled scrubby undergrowth, which, with low branches of the trees, makes it almost impenetrable. The undergrowth consists of seedlings of the trees, with Scaevola, Suriana, Achyranthes, Wedelia, Clerodendrum, and Ximenia, the whole tangled and laced with lianas of Ipomoea tuba and Canavalia. On rocky places there may be Pemphis acidula. Coconuts may be scattered here and there from nuts planted by the natives or dropped by accident.

In the northern Marshalls there is no particular organization to this mixture, except that when tall and dense, there is little or no undergrowth. In the southern Marshalls, Hatheway reports that the trees usually occur in small groups of one species, rather than mixed as individuals. What seems essentially the same forest may result from second growth after clearing and from new colonization on new land. There seems to be no special correlation with any of the several types of substratum. On the seaward sides, if they are to the windward, there is a transition to a dense scrub. In the interior of well developed Mixed Forest, Messerschmidia tends to drop out gradually, not reproducing itself in the shade.

Most of the recognizable forest types on atolls seem to be extreme variations of Mixed Forest consisting principally or entirely of one of the component species of this forest. Because the intergradation between all of these types and Mixed Forest seems to be complete, and since their actual developmental relations are not fully understood, they are, for the purposes of this review and to emphasize their lack of sharp limits, here regarded simply as variants. The principal ones are as follows:

a. Pisonia Forest--Pure stands of Pisonia grandis are a very common and widespread phenomenon on coral islands throughout the Indo-Pacific region. The distribution and some data on the occurrence of this species has been reviewed, recently, both by St. John (1951) and by Shaw (1952). Shaw suggests that bird guano may be required for the growth of this species, or at least for germination and establishment of its seedlings. However, healthy trees have been observed in absence of any noticeable guano. Germination of seeds must be a rather infrequent occurrence, as no seedlings of this species were seen in the northern Marshalls investigation.

A characteristic of many or most of these groves or forests is a layer of highly acid raw humus on the surface of the ground, and often, just beneath this, a layer of phosphatic sandstone or hardpan. There seems little doubt that this is a phenomenon dependent upon the presence of the Pisonia

(together with sea-birds), rather than controlling the distribution of the Pisonia. This relationship will be discussed in detail elsewhere. It has already been touched upon by Hatheway 1953.

This forest, up to 25-30 m. tall, commonly has a dense canopy, elephantine white trunks, spreading at the base into twisted root platforms, and little or no undergrowth except for Pisonia root sprouts. These are of quite irregular distribution, some trees having them, others not, even in the same grove. Fallen trees usually, but not always, take root wherever they touch ground, sending up a number of erect branches that become trunks. In dry regions Pisonia is more or less deciduous in the dry season, allowing more than usual light to enter. Birds tend to favor this forest for roosting and nesting; there are often hundreds or thousands of fairy terns, noddies of two kinds, red-footed boobies, and frigate birds nesting in the branches of a grove, and white-tailed tropic birds have been found nesting in cavities.

b. Ochrosia forest: One of the most striking atoll forest types is a pure dense stand of Ochrosia oppositifolia. These trees are up to 20-25 m. tall, with clean slender trunks, seldom more than 3 dm. through, and umbrella-shaped crowns of broad dark green leaves. These grow in contact, forming a canopy so dense that there is perpetual twilight beneath it. There are few seedlings of any other species on the ground, but those of Ochrosia are there in millions. The egg-like bristly fruits form a continuous layer on the ground, and the seedlings are of more or less even height, usually 3-4 dm., evidently reaching this height, dying and being replaced or not growing much further. If an opening of any kind is formed in the canopy, the seedlings beneath quickly grow up and fill it.

This forest does not seem to be found especially on any one type of substratum, being seen on sand, gravel, or broken coral rock. It has been observed particularly, as a continuous stand, in islands with a moderate rainfall. Apparently, once started, Ochrosia is able to replace most, if not all other species, at least in the moderate rainfall belt in the northern Marshalls. It has not been described from anywhere outside the Marshall Islands, though the tree is widely distributed in the Pacific.

c. Pandanus forest: In the Marshalls pure stands of Pandanus tectorius are uncommon and not of large extent. A solid stand was seen on Maria Atoll, Austral Islands, that covered an entire islet. Such stands have also been reported from the uninhabited atolls of the Tuamotus. Though Pandanus commonly branches toward the base, in dense forests the trunks are usually rather tall and straight before branching, with conspicuous prop roots holding up the bases and making walking difficult where the trees are close together. The crowns are pyramidal in shape, composed of enormously long sword-like leaves imbricated on the stem in three close spirals which give the tree one of its common names, "screw-pine." These leaves are provided with a row of stiff spines on the midrib and others along the margins. The leaves form a loose accumulation on the ground beneath the trees, where they retard the appearance of seedlings or herbaceous plants. Pandanus seedlings are able to start in denser shade than in Pandanus forest, but are not common in this type of forest, though they often form a carpet under isolated trees where leaves have not accumulated. Pandanus seems equally at home in almost any atoll habitat.

d. Messerschmidia forest: On some of the drier atolls, such as Pokak and Wake, low forest of Messerschmidia argentea is the dominant vegetation. The trees are not very close together and commonly preserve their perfect hemispherical shape. Their silvery gray-green leaves are fleshy and in extreme dry weather all but the youngest on the twigs drop off. Pure stands of this species often colonize new islets and may remain uninvaded by other species for a long time. On some islands a strip of this type, but of very much taller trees, closer together, and open beneath, may occur just back of the beach scrub. The trees sometimes, but rarely, reach 20 m. tall. Their trunks are twisted and freely branched. They are seldom dense enough to exclude a ground cover, which may be of grass (Lepturus, Thuarea, Stenotaphrum), Triumfetta procumbens, or Boerhavia, or, on rocky substrata, Fleurbaeya. Underbrush is not so common in this type, though Scaevola frutescens may be present, or Sida fallax. Ipomoea tuba lianas are frequently tangled abundantly in this forest, even in its driest manifestations. This type, also, seems to have little or no preference in substratum, but it is a pioneer type and will only persist under conditions which do not favor its more mesophytic competitors.

e. Cordia forest: In drier atolls Cordia subcordata often forms pure forests, though not of large extent. The trees may be close set and reasonably tall, but are commonly farther apart, at least the trunks, and with low, long widespreading branches that drag on the ground, become tangled and entwined, and make an impenetrable thicket. Often there is no undergrowth or ground cover at all. In the dry season this species may be briefly deciduous.

f. Barringtonia forest: Only one area of this has been observed, on Lae Islet, Lae Atoll, but it is such a striking type that it is worth looking for elsewhere. The trees were of enormous diameter, massive, 20-25 m. tall, canopy complete and dense, nothing on the ground except a colony of Peperomia. The ground in this forest had been covered, subsequent to the trees reaching a large size, by a deposit of large boulders to a depth of up to a meter. This should be looked for elsewhere, as the species is found everywhere in the tropical Pacific and Indonesia.

4. Pemphis forest:

On rock at or above high tide level, whether elevated reef rock, coral conglomerate, or beachrock, pure stands of Pemphis acidula, a densely branched small-leaved tree, are common. The trees are able to grow where pure sea water wets their roots at high tide. They reach 6-8 m. tall, are commonly gnarled and twisted, with trunks up to 2-3 dm. thick, rarely much more, of extremely hard and heavy wood. The lower branches, even though dead, are persistent and rigid, and as the trees grow very closely, the stand may be fairly impenetrable. Usually nothing grows beneath it. The general color of this forest, from a distance, is a soft bluish green, and the texture of the trees leads persons unfamiliar with Pemphis to describe it as looking like a conifer. This type is a fairly reliable indicator of rock substratum, but occasionally may be found on sand. Possibly these cases have rock at shallow depths, but this has not been investigated thoroughly.

5. Mangrove Forest:

Mangroves of a number of kinds may be found in shallow lagoon margins, in tidal ponds or swamps with outlets, and in depressions with no outlets. In open lagoons Sonneratia or Rhizophora are found, rarely Bruguiera conjugata. The latter is much more common in the depressions, either mud bottomed or rock bottomed, where it may be accompanied by Lumnitzera, Intsia, or Pemphis. The latter two are usually found on rock bottoms. In the ponds with outlets Rhizophora is commonest. In the Marshalls, where the depressions without outlets are commonest, there is some evidence that Bruguiera may have been placed there deliberately by man. This is certainly true in some cases (Schnee 1904). The fruits are used in making a dye.

6. Beach Scrub:

Generally along the seaward sides of islets, especially on the windward sides, on the ends, and to a lesser extent along the lagoon beaches, beach scrub may be found on scrub vegetation. This is usually preponderantly Scaevola frutescens, but with varying admixtures of small bushy specimens of Messerschmidia, Guetarda, Terminalia, Suriana, Pemphis, and, on lagoon beaches, sometimes Cordia, Sonhora tomentosa, and Allophylus. In different situations this has a vastly different appearance. On both beaches it commonly forms a fringe, principally Scaevola, along the edge of the forest at the top of the beach, merging with the forest on the landward side. If this is a lagoon beach or seaward beach on the leeward side its margin is abrupt, vertical or rounded, and it may be several meters tall. On the windward outer beaches, especially in the trade-wind belts, the top surface of the scrub slopes down in an inclined plane, continuous with the similarly "wind-sheared" top of the forest, to the top of the beach. Occasionally the edge of this has a scalloped appearance and the upper surface is grooved in the direction of the prevailing wind, the groves gradually disappearing landward. Depending on the physiography of the ends of the islands, the scrub found there may be merely a continuation of the fringe on the seaward side if it is a boulder beach, or, if it is a sand or gravel spit, a scattered to dense growth, principally Scaevola may be quite extensive, resulting from original colonization. On the lagoon side of such a spit, or lagoonward of the forest, a row of Scaevola or mixed scrub may catch windblown sand and form a low dune ridge.

7. Miscellaneous scrub types:

In the interiors of islands, especially of drier ones, different sorts of scrub vegetation may occasionally be found. On Pokak Atoll are areas of Scaevola 1-2 m. tall, often on exposed rock substratum. Such areas, on most atolls, would probably be occupied by Pemphis scrub or forest, but this plant does not occur on Pokak. A similar inland scrub has been reported by Christophersen (1927) from Christmas Island.

A thin scrub of Sida fallax, usually with Lepturus and other herbs, occurs in fairly large areas on Pokak and on Christmas Island, Canton, and other dry central Pacific atolls. This seems to fluctuate a great deal with wet and dry periods, the individual bushes partially dying during dry cycles, but with some branches continuing to flower. In some favorable localities this may reach almost 2 m. in height and be so dense as to somewhat impede walking. Small patches of this are found on dry islets in other atolls of

the northern Marshalls, often surrounded by forest. In places, as on Christmas Island, Messerschmidia trees, perfectly rounded on top, are more or less thickly scattered in the Sida scrub to form a park-land or savanna.

Hedyotis romanzoffiensis and Heliotropium anomalum form a dwarf scrub, usually rather sparse, on Christmas Island. In places Sida and Suriana may be added to this to form a mixed dwarf scrub. Herbs, such as Lepturus, Portulaca, and Boerhavia are commonly associated with this. It is usually not more than about 0.5 m. tall. Something similar occurs in openings in the Tuamotus, but little is known about it.

On Christmas Island, and perhaps, Jarvis, are small areas of loose scrub made up of Abutilon indicum. The bushes grow to 1-2 m. tall.

8. Lepturus Grassland:

On most of the drier atolls are patches, and on Pokak and Christmas large areas, of a bunchgrass vegetation of Lepturus repens, sometimes with admixtures of Heliotropium anomalum, Portulaca, Boerhavia, and other herbs. These seem, invariably, to have sand or fine gravel as a substratum, either pure or between the rocks. The bunches may be so close together as to form a continuous cover or may be widely separated, and may be very small to as much as 3-4 dm. tall. On Pokak this type of area is invariably undermined by the burrows of enormous numbers of wedge-tailed shearwaters. On Christmas Island there may be a scattering of Messerschmidia trees, giving a savanna effect. This is also somewhat true on Pokak. On some atolls, these Lepturus patches are often extensively parasitized by mats of Cassytha filiformis. On Christmas Island Lepturus is locally mixed with Tribulus cistoides or with Heliotropium anomalum.

9. Other Natural Herb Types:

On some atolls, as Taka, Bikar, Jarvis, and other rather dry ones, are areas where Portulaca lutea is dominant or in pure stands. The cover is ordinarily not complete. These are usually on rather freshly formed sand or gravel surfaces, and are probably short-lived, being invaded by other species rather promptly.

Mixtures of Portulaca, Boerhavia, and Lepturus may cover the ground sparsely to rather densely. On Christmas Island Christophersen (1927) described, also, areas of a pure stand of Boerhavia, which he said had grown over and killed the other plants.

On highly saline flats, usually near the lagoon, at practically high tide level, the vegetation is of scattered mats of Sesuvium portulacastrum. This vegetation has been noted on Wake Island, Canton Island, and Christmas Island, and probably occurs more widely, at least in the dry Pacific Equatorial and Phoenix groups.

10. Secondary Herbaceous Types:

During the war large areas on such atolls as Kwajalein, Eniwetok, Wotje, Jaluit, and others were denuded of their vegetation. Most of these

have scarcely been studied, but on Kwajalein and to a much lesser extent, Jaluit and Eniwetok, observations have been made. These areas seem, usually, to be occupied by mats of Ipomoea pes-caprae, Wedelia biflora, or Vigna marina. These may become so dense that invasion by woody species is greatly retarded. Wedelia tends to dominate in many such occurrences, and may form a dense mat one or even two m. thick, sometimes mixed with Ipomoea. On Lae Islet, Lae Atoll, a similar mat of pure Wedelia occupies an open meadow-like place of unknown origin in the forest. This did not change significantly between 1944 and 1952. The substratum was fine broken coral.

On abandoned compacted coral air strips, Fimbristylis cymosa (or atollensis) may get started as a pure stand and persist for some time, as on Bikej Islet, Kwajalein.

In 1945 an attempt was made to revegetate Kwajalein Islet and some others that were being used as active military establishments, by planting Cynodon dactylon. This has persisted in some places, but soon became invaded by other species, especially by Paspalum vaginatum, a similar sod-forming grass. The latter is now the commonest grass on Kwajalein Islet. Heavy traffic tends to discourage such plants as Wedelia and to favor such temporary weeds as the obnoxious Cenchrus echinatus, Eragrostis amabilis, Eleusine indica, and several species of Euphorbia. The weedy vegetation around such establishments is complicated by the great influx of new weeds brought in accidentally. Pluchea odorata and P. indica have become very abundant around most military bases, and for a while there seemed a probability that they would dominate the vegetation. However, where left reasonably undisturbed, Wedelia seems very able to smother them out.

11. Bogs and Marshes:

For present purposes bogs and marshes may be distinguished by defining the former as having a substratum of a spongy peat, the latter a substratum of soft muck.

Pits, artificially established for cultivation of taro-like plants, usually Cyrtosperma and Colocasia, occasionally sugar cane and other things, even ornamentals such as Hibiscus rosa-sinensis, are the commonest kind of marshes found on atolls. These are essentially pits dug down to below the water table in the centers of islets, then filled in up to the surface of the fresh or brackish water with vegetable refuse or compost, which rots and forms the muck substratum. Such pits vary from a few square meters to many hectares in extent. Cyrtosperma, a gigantic herb with great arrow-shaped leaves up to three meters or more tall, usually dominates these pits. This tends to crowd out Colocasia, which is often preferred as food. The starchy corms of these plants are the parts utilized, the tops of these being broken off and replanted. Many weeds occur in such places, the most aggressive being Alocasia, a giant aroid similar in appearance to Cyrtosperma but inedible, and Paspalum vaginatum. The latter, introduced recently in the northern Marshalls, has completely taken possession of many of these pits on Likiep and Ailuk. Other common weeds are Cyperus odoratus, Eleocharis geniculata, Jussiaea suffruticosa, Polygonum sp., and Athyrium sp.

Natural marshes occur on many atolls, being places where, for one or another reason, the ground surface dips beneath the water table. The bottom is a soft mud whose composition has not been investigated. Cyperus javanicus, Jussiaea, and various weeds are commonly found here.

On Washington Island, at one end of the freshwater lake, is a peat bog of some extent. The vegetation of this is a solid stand of Scirpus riparius, invaded around the edges by Cyrtosperma and Polypodium scolopendria. This is a rather rare or possibly unique occurrence on an atoll and has been well described by Wentworth (1931) and Christophersen (1927).

12. Terrestrial algal vegetation:

The land algae have been little investigated on atolls. There are, of course, the usual epiphytic unicellular green and blue-green algae on tree trunks and in lichen association with fungi, and microscopic algae on moist ground. There are algal mats in pools, both blue-green and green. On the wet bottom of a depression on Wake Island was noted a luxuriant fur-like growth of Enteromorpha. Almost nothing is known of the composition of most of the algal vegetation. Two physiognomic types are apparently so widespread as to be almost universal in their respective habitats. These have attracted some attention from other than vegetation students. They are as follows:

a. Surface discoloration on limestone rocks: Rocks exposed above high-tide level, whether consolidated material or loose boulders and cobbles, though white, pinkish, or very pale brown in color within, are ordinarily colored from a blue-gray to black. On close examination this is found to result from a layer as much as several mm. thick in which the rock is green in freshly broken cross section. Often the inner margin of this layer is more strongly colored than the intermediate depths, while the outer surface seems black. When the limestone is dissolved away in acid this color is found to be due to unicellular blue-green algae belonging to the Chroococcales. There have been various observations on its effect on the hardness and decomposition of the surface layers of the limestone, but no one, as yet, has separated out the effects which are due to the algae from those with other causes. Also, nothing is definitely known as to the origin and differences in intensity of color. It has been suggested by Teichert (1947) that the color is in proportion to the age of exposure, and that this might be a means of dating, relatively, the shingle deposits. Not enough is understood about this, as yet, to make any such conclusions dependable. It has been noticed, on Pokak Atoll, that where there is much abrasion by rolling around of loose material the algal layer is kept worn thin or is absent.

b. Algal crust on coral sand: On most areas where there is open sand, either with no other vegetation or between bushes of sparse scrub or tufts of sparse bunch grass, the surface of the sand for the first few millimeters is caked into a crust, held together by gelatinous blue-green algae. The general color is gray to blackish, but appears greenish when moist. When very dry such a crust, if well developed, may crack and curl up or wrinkle. The algae forming this crust are, so far as known, principally, Hassallia byssoidea, Scytomema ocellatum, and Porphyrosiphon fuscus, all filamentous Myxophyceae, and Gloeocapsa alpicola, a gelatinous colonial form (Taylor 1950).

This crust has attracted some attention as a possible source of fixed nitrogen in atoll soils, since it has been demonstrated that certain blue-green algae are able to fix atmospheric nitrogen. A limited amount of work has been done toward finding out if this is actually the case, but not enough has been done to yield any definite results. The crust undoubtedly serves an important function in retarding wind drift of fine sand.

13. Marine Seed-plant Vegetation:

On sandy, quiet-water shores in the western Pacific, Indian Ocean, and Caribbean Sea several genera of marine spermatophytes, commonly called "sea-grasses" tend to form a sod-like vegetation, holding the surface layers of sand in place by their entangled rhizomes. This type of vegetation is probably not unusual in the lagoons of atolls, but has scarcely been reported from them. Two occurrences are known. One is a tiny patch of Thalassia hemprichii at the outlet of a mangrove swamp on Ailinglapalap Atoll; the other is a long strip of sod of the same species at low tide level on the lagoon beach of Ujelang Islet, Ujelang Atoll, both in the Marshalls. Undoubtedly this will be found to be more widespread, especially in the Caroline atolls when they are more adequately investigated. It is a common feature of barrier reef lagoons around high islands in Micronesia.

This vegetation is often referred to as "turtle-grass" and is said to be the principal food of the green turtle. It is rather difficult to account for the abundance of turtles in the northern Marshalls when there is so little "turtle-grass" without assuming either other foods or extensive migrations. Such migrations are known in the western Indian Ocean, where the turtles breed on some of the atolls, but migrate to the Mozambique Channel, hundreds of kilometers away, to feed during a part of the year. Their stored fat apparently keeps them alive during the breeding season. It would be very interesting to know if there are such migrations of turtles in the Pacific.

14. Marine Algal Vegetation:

The actual algal communities of atolls have not been sufficiently studied to enable a very significant summary to be made. A zonation is observed, even by the casual collector, which will be outlined below, beginning with the outer edge of the reef. The problem is complicated by the fact that the zonation is by no means the same on windward and leeward sides, by seasonal fluctuations in abundance of species, and by fluctuations in response to available nutrient material dissolved in the water. An excellent example of this is given by Taylor (1950), when he notes that Enteromorpha was scarcely seen when he arrived on Bikini in 1946 but had become very abundant during the time the party spent there, presumably in response to the pollution of the lagoon by sewage and refuse from the large establishment set up there for the atomic-bomb tests. There is also much difference in algal floras, at least as to relative abundance of species, from atoll to atoll.

a. Algal ridge (Lithothamnion ridge of most authors): At the outer edge of the seaward reef, especially on the windward side, calcareous red algae of the genus Porolithon and possibly other genera form a massive accumulation

of limestone that is generally built up several feet above the general level of the reef flat. It is of a bright pink color, rough to rather smooth, and is very resistant to the pounding of the waves. Many people believe that the strength of this indurated edge of the reef protects the whole structure from pulverization by the breakers. The height to which this ridge is developed is more or less in proportion to the constancy and roughness with which waves break against it. Frequently it is entirely absent on the leeward sides of atolls. On the leeward sides, also, there may occasionally be a small such ridge developed on the edge of the lagoon reef, in response to lagoon waves.

b. The moat: The depressed area or trough dipping below low tide level just behind the algal ridge, landward, sometimes represented by numerous tidepools, is usually filled with corals and has a considerable diversity of algae. There may be Laurencia in abundance, Liagora, Avrainvillea, Codium, Halimeda, and many other genera. They do not, however, form a continuous layer, except sometimes in the case of Codium.

c. The reef flat: This relatively smooth, gently sloping area, sometimes very broad, extending from high-tide level to low-tide level, is mostly covered by a continuous layer of algae, sometimes very thin, and little else. Over large areas Cladophoropsis is dominant, forming a dense felt which catches fine calcareous sand. Over other areas this is replaced by a fur of Jania, also a collector of sand. Padina is common in other places, though not very frequent in the northern Marshalls. In more restricted areas, near high-tide level, may be putty-like masses of silt held together by the very fine filamentous Schizothrix. In still other places there is only a slimy film of microscopic algae of several sorts. On the under sides of boulders strewn on this flat Microdictyon is common, and there is some Dictyosphaeria. In certain places the bottom is covered by a crust of a thin encrusting calcareous red algae, or by small pebbles so encrusted (nodular). There may be a rough correlation in the distribution of these communities with the duration of exposure above water, but it has not been worked out very well, as yet.

d. The lagoon reef flat: The lagoon reef flat, the shallow shelf extending out a short distance from the inner shore of the islets, is not generally a region of abundant algae. It is usually either sandy or covered by rubble. In the northern Marshalls, Halimeda stuposa and a species of Udotea of similar habit grow in sandy places as scattered tufts, with their curious "pseudostipes" buried in the sand. Between the boulders of rubble deposits a little Caulerpa may be found. Tiny tufts of small filamentous red algae also grow here, sometimes on the sea anemones that are common here.

e. The passage between islets: Here water is usually flowing in one direction or another. Luxuriant colonies of Halimeda, several species of Caulerpa, and, rarely, Turbinaria ornata grows at or below low tide level. The rocks, both above and below low-tide level are slippery with a film of very small algae.

f. The leeward reef where there are no islands: Where this is not exposed at low tide, except for coral heads and boulders, coral is very abundant and algae are scarce. On Ailuk only a species of Liagora seemed to be common in such a place, forming scattered tufts growing on the coral and boulders. Where the leeward reef is exactly at low-tide level or slightly

above it, it is often covered by a platform of Porolithon, bordered by a slight Lithothamnion ridge. In cavities in this are Halimeda and Caulerpa.

g. The lagoon bottom: This has not been studied much, but in the northern Marshalls it is known to be covered at least in some areas, by a stand of Halimeda growing in such abundance that the lagoon bottom sediments are in places almost entirely made up of its calcareous skeletons. In Ailuk a species of Caulerpa was snagged from the lagoon bottom by a fishline, so there may be some areas where it is abundant.

Vegetational Patterns

The original arrangement of the various types of vegetation on atolls has been very largely obscured because coconuts have been planted indiscriminately almost everywhere. The present pattern is for the greater part of the larger islets to be covered by coconut plantations, leaving a belt of scrub and scrub forest on the windward sides of islets on the windward sides of atolls. This protects the coconut trees from excess wind and salt spray. The outer edge of this belt is usually a fringe of Scaevola, which gradually merges with the mixed forest which lines the coconut groves. Very narrow islets and parts of islets, such as sand spits on their ends, seldom have coconuts, but usually have mixed scrub, usually dominantly Scaevola and Messerschmidia, or if the narrow place is rock, the vegetation may be Pemphis scrub. Along the lagoon sides of the coconut groves, there is usually a thin line of scrub or a row of trees.

From the remnants of native forest remaining here and there, and from a consideration of the present distribution of trees on the islets mostly occupied by coconut groves (Hatheway 1953), some idea may be obtained of the original patterns. It is apparent that some species of plants--and consequently, where there are so many types dominated by single species--some vegetation types are less halophytic than others. Such are Ochrosia, Pisonia, and mixtures of these with Intsia, Allophylus, Pandanus, Pipturus, Guettarda, and others, but lacking Messerschmidia. These types tend to be toward the interior of islets, and surrounded by more halophytic and scrubby forest and beach scrub, dominated by Messerschmidia, Scaevola, Pandanus, Terminalia, and Guettarda. The width of this more halophytic belt, especially of the outer beach scrub, is greater on the seaward and especially the windward sides. In the wetter atolls, after they are largely in coconuts, breadfruit groves and solid breadfruit forest seem to coincide in distribution with those parts of the islets where the more mesophytic forests formerly occurred. It has been suggested (Fosberg 1948, 1949) that the distribution of the more mesophytic types might be correlated with a lens of relatively fresh ground water, better developed on the wider islets. The existence of such a lens and its correlation with the distribution of some plants, such as breadfruit, has been amply demonstrated since, though there seems reason to think that the influence of salt spray and wind is much greater than previously suspected. And too little is yet known about the seasonal fluctuation in salinity in these shallow ground water lenses.

On very dry islands the occurrence of Lepturus grassland seems to coincide somewhat with sandy areas, completely rocky places being more likely to be occupied by scrubby forest of Messerschmidia, or, in places, Cordia or Pisonia. ./.

Pemphis forest or scrub is practically always found on rock surfaces at or above high-tide level. Suriana, which sometimes forms a rather pure scrub, but more often is a component of mixed beach scrub, has only once or twice been seen or recorded from anything but sand. Sophora tomentosa is usually found on sandy lagoon beach ridges.

Entirely too few atolls have been at all carefully studied to make more than the roughest generalizations possible. The only vegetation maps of atolls that exist are those of Arno (Hatheway 1953). Without such maps, similarities in distribution patterns are hard to see.

Most needed future studies

The most urgent need is for information on the few remaining bits of native vegetation on atolls in various parts of the world. Such studies of the more remote atolls in the northern Marshalls during 1951 and 1952, though very brief, yielded a great deal of information. And remnants of original vegetation will disappear extremely rapidly.

All opportunities should be taken advantage of to look into the salinity relations of the different vegetation types and of individual species of plants. Any ground water study should be accompanied by careful notes on the vegetation. Information is especially desired on the effects of seasonal fluctuations in salinity.

Anything contributing to an understanding of successional relations of these vegetation types will also be important. Observations as to what species can establish themselves in the shade of what others, as to what common species are seen dying out or lacking in some types, and as to changes taking place over the years in areas completely devastated during the war, are all especial desiderata.

Whether or not the prominence of types consisting of single species is a general atoll phenomenon or only characteristic of the relatively dry northern Marshalls is not known. And in any event, the explanation for this is of great interest. Whether it is a function of the extreme habitat, or of the very small floras, or of both should be looked into.

The cause for the areas of unhealthy or dying coconut plantations in the Marshalls, and whether such a phenomenon is found elsewhere, are matters of more than academic importance.

Whether pure Ochrosia forest is found elsewhere than in the northern Marshalls is not known. The nature of the yellow patches in this forest, also, seems of fundamental importance. This is especially so if it can be shown that it is an effect of the vegetation on the habitat.

Any influence exerted by the vegetation on the habitat is of great interest. The only clear-cut case familiar at present is the formation of phosphate rock under the influence of Pisonia forest. Phosphate exhaustion in coconut groves is suspected. Influence of beach scrub in the piling up of sand dunes is also probable. Protection of the land surface against mild typhoons is another possibility. Binding of sand by blue-green algae against

wind erosion is still another. The effect, if any, of algae, in the formation of beach or reef sandstone needs to be determined. There are many others, but most studies have been so hurried that it was not possible to gain more than an inkling that something was happening. The careful study of any ecological process is one of the most important things that can be done to gain the understanding of atoll ecology. The student must, however, be cautioned against the tendency to explain everything in terms of the one process intensively studied. The vegetation is an expression of the interaction of many such processes, and the unraveling of their effects is the ultimate, though probably unattainable objective of the study of vegetation.

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